APRIL 1953

Journal

VOL. 45 • NO. 4

AMERICAN WATER WORKS ASSOCIATION

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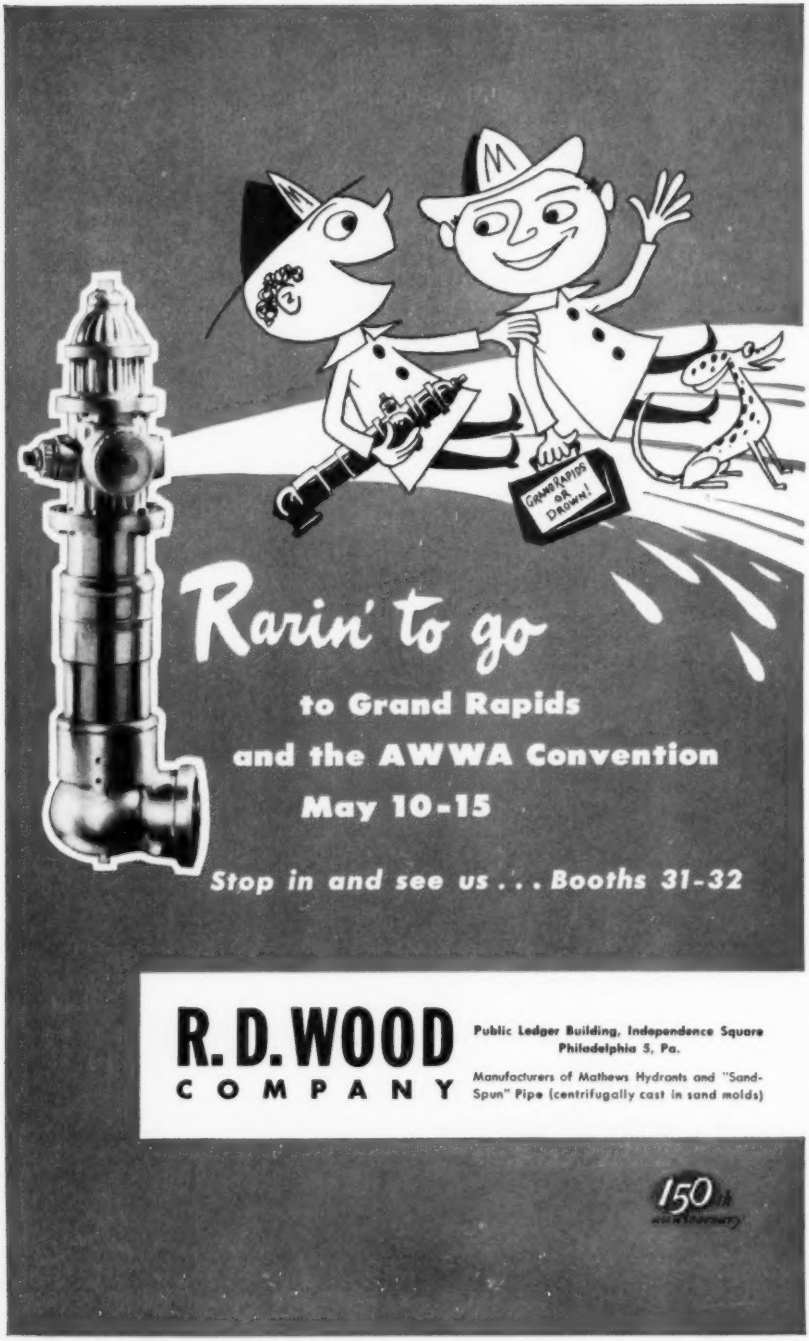
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Journal

AMERICAN WATER WORKS ASSOCIATION

April 1953

Vol. 45 • No. 4

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Indexed annually in December; and regularly by *Industrial Arts Index and Engineering Index*.

Microfilm edition (for JOURNAL subscribers only) by University Microfilms, Ann Arbor, Mich.

All correspondence relating to the publication of papers should be addressed to:

Harry E. Jordan, Secretary—521 Fifth Avenue, New York 17, N.Y.

$7.00 of members' dues are applied as a subscription to the JOURNAL; additional single copies to members—50 cents; single copies to non-members—75 cents.

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Journal AWWA is published monthly at Prince & Lemon Sts., Lancaster, Pa., by the Am. Water Works Assn., Inc., 521 Fifth Ave., New York 17, N.Y., and entered as second class matter Jan. 23, 1943, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Accepted for mailing at a special rate of postage provided for in paragraph (d-2), Section 34.40, P. L. & R. of 1948. Authorized Aug. 6, 1918.

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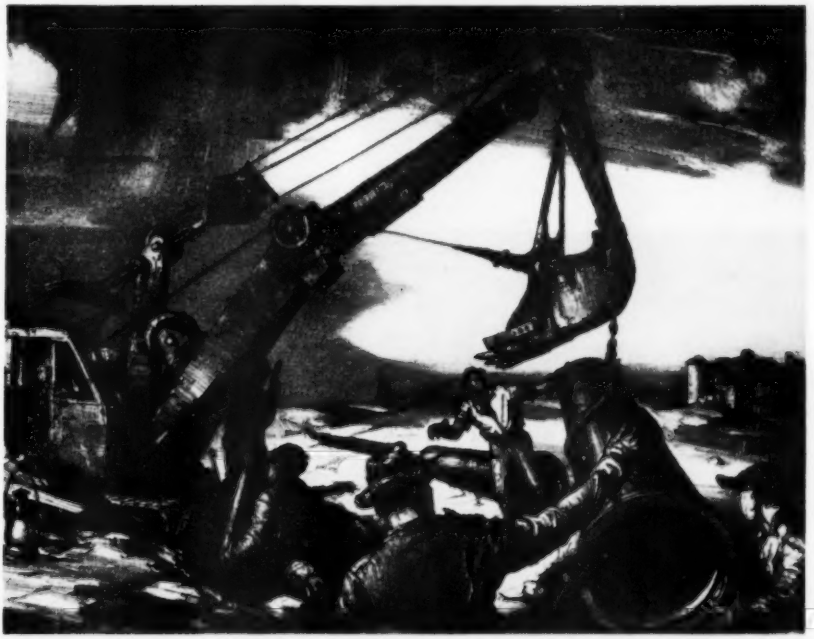

Lithographed on stone for U. S. Pipe and Foundry Co by John A. Noble, A.N.A.

THIS RURAL SCENE is not an unusual background for cast iron pipe. The installation might be a water supply line for a city nearby. It could be a sewer force main leading to a treatment plant. Also it might be a gas transmission line for a city, in which case it would unquestionably be of the mechanical joint type.

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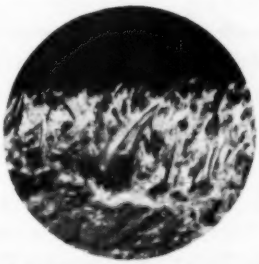

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Apr. 16–17—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civ. Eng., Univ. of Nebraska, Lincoln, Neb.

Apr. 16–17—New York Section at Mark Twain Hotel, Elmira. Secretary, R. K. Blanchard, Vice-Pres. & Engr., Neptune Meter Co., 50 W. 50th St., New York 20, N.Y.

Apr. 16–18—Pacific Northwest Section at Multnomah Hotel, Portland, Ore. Secretary, O. P. Newman, Exec. Vice-Pres., Boise Water Corp., Boise, Idaho.

Apr. 16–18—Arizona Section at San Marcos Hotel, Chandler. Secretary, M. V. Ellis, Supervisor, Sewage Treatment Plant, Phoenix, Ariz.

Apr. 22–24—Kansas Section at Broadview Hotel, Wichita. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina, Kan.

Apr. 24–25—Montana Section at Kalispell Hotel, Kalispell. Secretary, Arthur W. Clarkson, Asst. Director, Div. of San. Eng., State Board of Health, Helena, Mont.

June 10—New Jersey Section Summer Outing and Inspection of Johns-Manville Research Center, Finderne. Luncheon at Martinsville Inn, Martinsville. Secretary, C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1, N.J.

June 17–19—Pennsylvania Section at Hershey Hotel, Hershey. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg, Pa.

OTHER ORGANIZATIONS

Apr. 6–30—Lectures on prestressed concrete, Monday and Thursday evenings at Newark College of Engineering, 367 High St., Newark 2, N.J. Details from Special Courses Div.

AWWA ANNUAL CONFERENCE

Grand Rapids, Mich. May 10–15, 1953

All reservations will be cleared through the AWWA office. The hotels have agreed to accept no reservations for the 1953 Conference except as they are requested on the standard form, through the AWWA.

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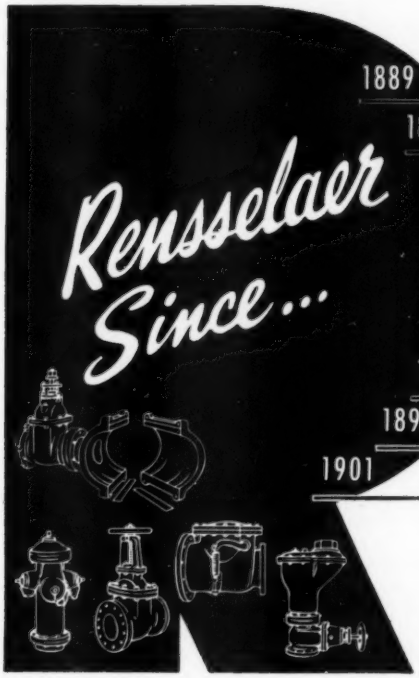

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Sales representatives in principal cities

Coming Meetings

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Apr. 20–21—Industrial waste disposal regional conference at New Orleans, La. Details from H. M. Conway Jr., Director, Southern Assn. of Science & Industry, 5009 Peachtree Rd., Atlanta, Ga.

Apr. 24—Ohio certification exams for water and sewage plant operators. Details from J. E. Richards, Secy., Advisory Board of Examiners, 306 Ohio Departments Bldg., Columbus 15, Ohio. Applications must be filed at once.

May 4–6—Purdue Industrial Waste Conference at Purdue Memorial Union Bldg., Lafayette, Ind. Reservations from Purdue Union Club, Fowler Hotel, Cedar Crest Hotel, or Morris Bryant Hotel. Details from Don E. Bloodgood, Civil Engineering Bldg., Purdue Univ., Lafayette, Ind.

May 11–15—National Fire Protection Assn., Palmer House, Chicago. Details from Percy Bugbee, Gen. Mgr., 60 Batterymarch St., Boston, Mass.

May 12–14—American Public Power Assn., Sheraton Plaza Hotel, Boston. Details from Alex Radin, Gen. Mgr., 1757 K St., N.W., Washington 6, D.C.

May 31–June 4—Municipal Finance Officers Assn., Hotel McAllister, Miami. Details from Joseph F. Clark, Director, 1313 E. 60th St., Chicago 37, Ill.

June 16–19—Spring Technical Meeting and Welding Exposition of American Welding Society at Shamrock Hotel, Houston, Tex. Details from Society at 12 E. 41st St., New York 17, N.Y.

June 21–27—Congres International de Chimie Industrielle, Paris, France. Details from Societe de Chimie Industrielle, 28, Rue Saint-Dominique, Paris VII, France.

June 29–July 3—American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City, N.J. Details from Robert J. Painter, Exec. Secy., 1916 Race St., Philadelphia 3, Pa.

Sept. 28–30—New England Water Works Assn., Poland Spring House, Poland Spring, Me. Details from Joseph C. Knox, Secy., 73 Tremont St., Boston 8, Mass.

Oct. 8–9—National Conference on Industrial Hydraulics, Sheraton Hotel, Chicago. Details from Otmar E. Teichman, Conference Director, Illinois Inst. of Technology, 35 W. 33rd St., Chicago 16, Ill.

Oct. 13–16—Federation of Sewage and Industrial Wastes Assns., Municipal Auditorium, Miami, Fla. Details from W. H. Wisely, 325 Illinois Bldg., Champaign, Ill.

Oct. 26–29—American Public Works Assn., New Orleans, La. Details from D. F. Herrick, Exec. Secy., 1313 E. 60th St., Chicago 37, Ill.

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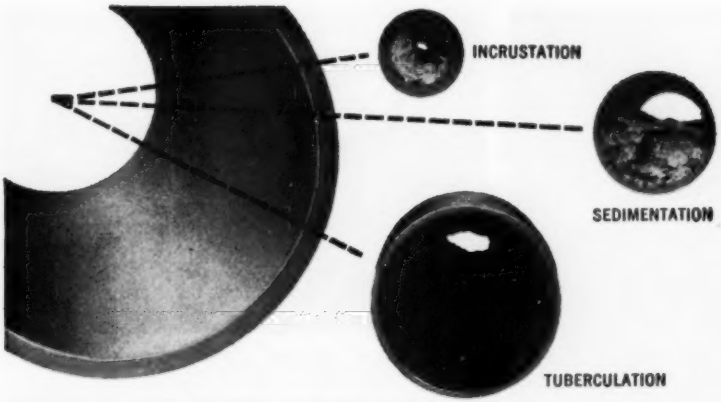

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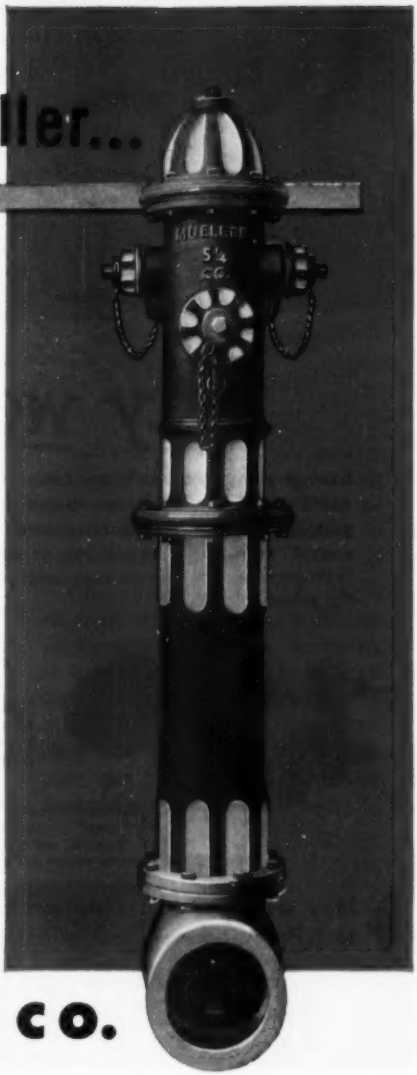

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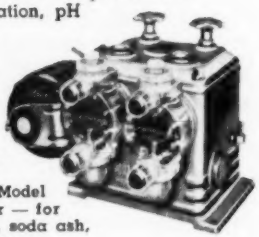

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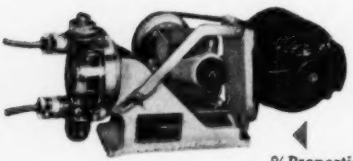

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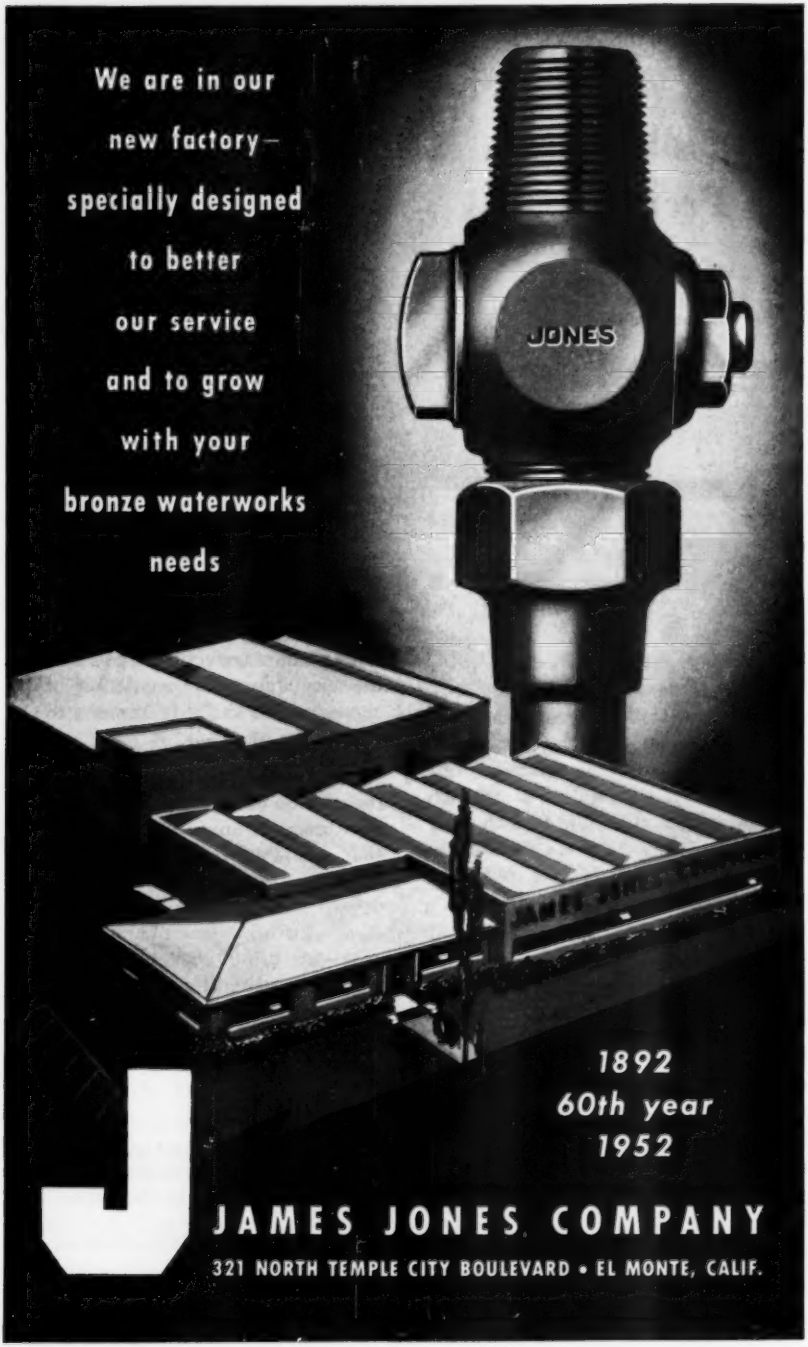
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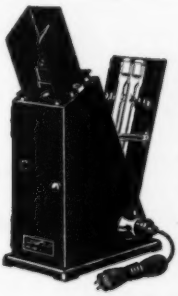

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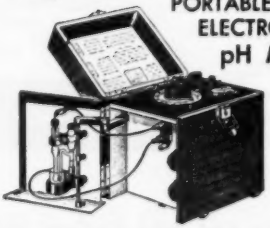

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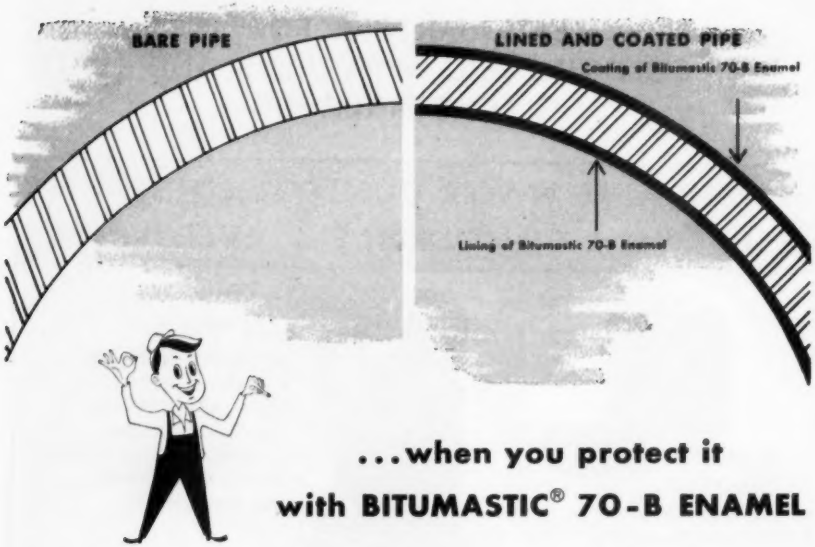

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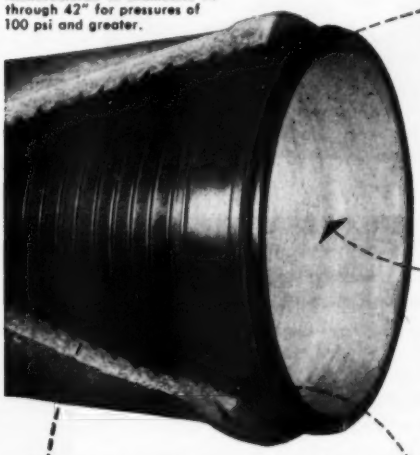

1 Steel cylinder provides a positive water seal or membrane as well as part of the required total steel area*. (Thickness of the cylinder varies according to pipe diameters and general design requirements). Each cylinder is hydrostatically tested to a unit stress of at least 22,000 psi.

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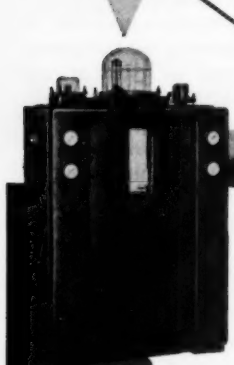

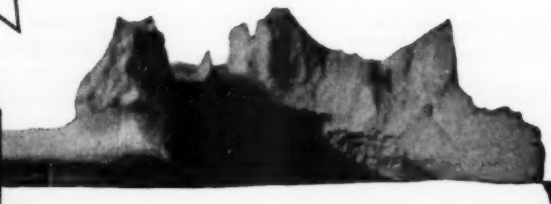

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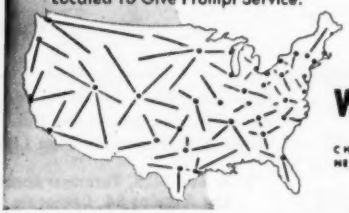

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 45 • APRIL 1953 • NO. 4

A Financial Man Looks at the Water Business

By George I. Mc Kelvey Jr.

An address presented on Oct. 24, 1952, at the New Jersey Section Meeting, Atlantic City, N.J., by George I. Mc Kelvey Jr., formerly a partner in Darby & Co., New York, and now an associate of Tucker, Anthony & Co., New York.

I WILL not muddle along interminably about the technical side of the bond business. Instead, I will start where I logically should end, by giving you six essentials for an ideal water revenue bond issue: [1] a municipality with a steady, conservative growth; [2] an unlimited potable water supply, not too distant; [3] an enterprise cost that water charges can easily defray; [4] legal steps approved by a competent law firm; [5] a covenant to maintain water rates sufficient to cover all charges; and [6] good management, meaning a water department run by water experts and free of political interference.

A generation ago virtually all municipal bonds were what we call "GO's"—general obligations of the city backed by its full faith, credit, and taxing power. The chief buyers were insurance companies, savings banks, a few trust funds, and some private individuals. Tax exemption meant little, for income taxes only began in 1912, and even by the start of World War I the topmost bracket was a mere 7 per cent.

One "purpose" bond was as good as another—school, water, city hall, or whatnot. But gradually we noticed that the astute buyer would often ask for a water bond, so long as the price was the same. We agreed with his reasoning: First, when men banded together in cities for protection, water was the most essential city service. Second, in a financial pinch, although the taxpayers might not be too anxious to pay on, say, a city hall bond, they would exert themselves to continue paying on their water debt. Finally, many cities, in computing their net debt for borrowing purposes, were allowed to deduct water bonds, a fact

which, in a way, elevated them from the status of a "debt" almost to that of an "asset."

Early Revenue Bonds

Time passed. We found cities where water funds were segregated, by law, from other city monies, and for such water bonds we were able to get a higher price than ordinarily. Eventually the water revenue bond was born. If you study the matter at length, you always come up with two diametrically opposed answers accounting for its birth, each of which seems to be right. Did the buyers' preference for water bonds, coupled with the extra value added by segregation of water funds, germinate the idea? Or was it sired by dishonesty in the womb of evasion? Let us see how they both came to be right.

In 1925 a financial firm brought to the New York market the first issue, of size, payable solely from water sales and having no property tax behind it. It was a $7,000,000 issue of San Antonio, Tex., 5½ per cent bonds. There was some question whether the market would absorb the entire issue. The bonds were not a "legal investment" for saving banks, and they had no "rating" given them by those services which give numbered or lettered values to securities. The main appeal was to insurance companies, as well as to a new group of investors which had cropped up, for, you may remember, income tax rates during World War I had gone way up to a top of 73 per cent and were receding but slowly.

The buyer, however, sensed that something was wrong. He wondered why, if a city wanted water, it was not willing to pay for it with old-fashioned GO bonds, instead of hiding behind clauses that made it appear the city would evade payment if troublous times came. The buyer was partly right in his fears, too, as many an early issue of these new bonds was voted by the taxpayers with at least some dishonest thinking entering into the picture. I have heard city officials point out how real estate could never be taxed to pay the bonds and how, once they were all paid off (through revenues), the people would own the water plant—free, for nothing. The taxpayer was led to believe that there was some magic in the scheme, that he was putting something over on someone even though he was not quite sure who that someone was.

Sometimes, in those earlier days, he put something over on himself and paid too much for his water plant. For one thing, the big investor demanded a higher coupon rate, perhaps a full 1 per cent more. If it cost San Antonio only ½ per cent, it would amount to $700,000, or 10 per cent of the total loan. Then, if you capitalize both the increased underwriting profit charged and the loss of some of the taxes to the city when the plant changed from private to public ownership, the overpayment could easily have reached 12 per cent or more.

Of course, in some places, the issuance of the revenue bond instead of a GO was a necessity. Take a city nearing its debt limit where GO water bonds were not deductible when computing net debt. There the revenue bond (not legally a debt) was mighty helpful. A city limited by law to a tax levy of so much on each $1,000 of assessed valuation was also helped, for the water bill was not a tax. But if the aim was to avoid liability, there was no magic in the formula at all,

because the "sufficient-rates" covenant simply meant that the man who turned the water tap had to pay the bill, one way or another.

Despite this, the period right after the Great Depression found the market being flooded with all kinds of revenue bonds. Municipalities had defaulted on their debts because John Q. Public simply did not have the wherewithal to pay his taxes. This made the tax bill seem onerous, which, in turn, engendered the thought that the tax bill should be lightened. The false magic of the revenue bond seemed to offer a way out.

Popularity With Investors

But whatever was in the taxpayers' minds, the investor by now knew that the basic security behind water revenue bonds was good, even if it did sound evasive. That sufficient-rates covenant was enough for him, and the market broadened steadily. Furthermore, he felt that the revenue bond was more businesslike than the GO, because the limit on the debt created was "economic" rather than "legal." City debt limits are fixed at some percentage of assessed valuation, but who is wise enough to say whether a limit set in prosperous times might not be frightfully topheavy when the next slump comes? There are dozens of places for errors in judgment. With revenue bonds, you just do not issue more than conservative income estimates can pay off.

Even defaults did not hurt the credit. I dare say they strengthened it, for water revenue defaults have mostly been confined to a few small places. In one instance, the town fathers, when taken to court, realized the effectiveness of the sufficient-rates covenant and promptly made good the default. The only big case I recall was in Texas, and that was a bad adventure from the start. After the bonds had been declared invalid the bondholders sued to recover the plant property and won. The court said, however, that, as the plant was necessary for "public peace, health, and safety," the creditors could not have the physical plant but they could have its money value. That is strong language.

Today a variety of methods are used in water financing—GO water bonds, water districts, commissions, authorities, and so on. The authority has lately become popular in Pennsylvania in places where political boundaries have to be crossed. That is one of New York's problems. I recall only two water revenue issues in New York State, by Utica and by the Suffolk County authority. Other authorities exist on paper in upstate New York, each created under a separate legislative act. There is no general authority act under which a group of places can band together for a common water supply. The comptroller has a committee studying the situation, but, because of technical difficulties, a constitutional amendment would probably be required. Many years ago a similar problem was resolved in New Jersey under the Passaic Valley Water Commission, where each municipality issued its own GO water bonds to pay for its share of the project.

In the future we may see some brand new methods of financing water system expansion. Kansas is working on "watershed districts" to control runoff. Incodel may end as a vast water district covering all or most of three or four states. There may be hydroelectric and water combinations.

One plan provides that local utilities will guarantee a municipal water project to obtain power for peak load service. This is cheaper than building standby plants.

But to come back to today, revenue bonds, instead of not being rated, or at best poorly rated, by the investment services, are in a much different situation. A recently compiled list of 58 cities showed that, in 29, the GO bond and the water revenue bond had exactly the same rating. In 24, the revenue bond rated higher, while only in 4 was it lower. That is coming a long way.

Nor do I believe that revenue bonds have reached the height of their popularity, for I cannot think of any more satisfactory record of continuing punctuality in revenue collections than the water bill. Gross billings and actual collections are nearly the same. If today there is a difference in the interest rate between the two types of bonds, it is very small, and it is not necessarily a matter of credit. It may be due to the fact that revenue bonds are still not a "legal investment" for savings banks and trust funds in the big-money states of New York, Massachusetts, and Connecticut. But even there a change has occurred, for such institutions now buy small amounts of nonlegals for surplus account or under the so-called " Prudent Man Investment Law."

Just what is a prudent man? I recall that, in the depression days, when legal investments like New York City bonds were selling in the high 70's, Cleveland and Cincinnati in the 60's, Jersey City in the 50's and Detroit around the 30's—that means $300 for a $1,000 bond—the San Antonio nonlegal revenue bonds never sold below the upper 80's.

Need for Education

Some sage or wit once said that in 4,000 years of history there were only three businesses that never went out of existence for lack of demand—sex, food, and amusement. It must have been a wit, for had it been a sage, he would also have included water in that list. And that makes me wonder why water is not sold at a price befitting its value. Maybe someone should start a campaign to glamorize water in the Hollywood manner. The beer companies, using your water at times, glamorize their product. One cereal company tells us how its particular kernels "snap, crackle, and pop" in the breakfast dish. But poor old water—all it does is come from the tap in a limp, listless, lusterless, glamorless stream.

Or is a two-pronged educational program, for the customer and the rate-making officials, the answer? You wince when you see the land or labor costs of an earlier generation frozen into a rate structure. The nearest thing to a consumer educational campaign in the East was the drought of a couple of years ago, and that was accidental. I do not mean a campaign just at rate-raising time, although some cities—Miami, Fla., Trenton, N.J., Akron, Ohio, and Phoenix, Ariz., to mention a few—have done that with good results. Perhaps that is enough to prove my point. I assume that many of you have talked to your friends about water. I have, and I am constantly amazed at how little they know about it and how much they take for granted. Few realize its low cost per gallon or what a dishwashing machine uses. I cannot resist telling about a charming lady I know who was busily wetting down her lawn as we talked. Behind her was a load of manure she

planned to spread for top dressing. When I mentioned that the water she was using cost less than 10 cents per ton, she grinned broadly and, nodding to the pile of manure in the driveway behind her, said, "And just think, I paid $5 a ton for that stuff."

An annual water bill of $16 for a family of four is not unusual. My own last year, for a household of eight, came to $29.65. Now, I heat my hot water by a little pot stove, which even the gas company admits is the cheapest way to do it. Why, then, did I have to use $73.50 worth of coal to heat just part of that $29.65 worth of water? Cockeyed economics!

I truly believe it is because water is so cheap that we are so careless with it. In Miami, after a successful campaign for higher rates, the first effect was a drop in consumption. Maybe that proves both points I am trying to make. Today we pay $25,000 for a $10,000 house. We can still buy a good dollar dinner but it costs us $3.50, and all I can recall is one small rise in our local water rates some ten years ago. Please do not misunderstand me. I would not advocate higher water charges just so someone can make more money. But if I read the signs right, population figures still climb and the home without numerous water-consuming appliances is a rarity nowadays. A recent report said that, of each 5,000 new houses being built monthly in the Los Angeles area, 4,000 have a disposal unit in the kitchen sink. Is it not true, then, that the nation faces the need for great expansion in its water facilities? Financial emphasis today is largely on highways, with schools a close second. Tomorrow it could logically be on water. Salt Lake City, Utah, has just permitted a 4-mill tax to build up a water and sewer expansion fund. Some places have funds in hand, I know. I am doubtful, however, that many places are so fortunate, but there is one thing I am not doubtful about—I know who is going to be blamed if the well runs dry!

I am afraid the customer does not know what the score is. Low rates may look fine to him, but they do not always benefit him in the long run and he should be so told. There is a certain city where the taxpayers learned the hard way. To reduce taxes, an economy program provided for improvements and liquidated the debt. It looked great, for in 15 years they were quite debt free and periodicals were carrying their "success" story. But, quite unnoticed, trade had dwindled as the city took on a run-down-at-the-heels appearance. Facilities slowed up. The light dawned after fire insurance rates had been boosted because both fire and water facilities were deemed inadequate for an emergency. The taxpayers found that their saving on taxes had been lost in diminished business and higher insurance rates. Then they took steps to correct it.

Can the water customer be sold an idea in advance? Recently I studied some figures on an $8,000,000 water revenue issue. The customer's annual average bill was approximately $35. A 20 per cent rate rise would have sounded big, but it would mean only $7 a year, the price of one pack of cigarettes per day for a month. But see what it would accomplish! First, all those $7 increments would accumulate every year. Second, those accumulations would earn interest. Third, there would be a saving of, say, ¼ per cent on the bond's coupon rate, for that extra 20 per cent collection would create a much better security. And fourth, that money saved would also earn interest.

The end result, without resorting to compound interest, would have meant an expansion fund of more than $7,000,000 by the time the last of those $8,000,000 bonds was paid off. I know that is a theorist's dream. But does it have to be?

Employment of Consultants

This leads to another point. With the volume of municipal finance running heavier every year, the time has arrived when a financial consultant could be profitably employed by a bond issuer for the entire period from the inception of a project until its bonds are brought to market. The larger investor has dozens of new issues to study each week. Neither his staff nor the bond house can give each issue the time it really deserves. The result is that the issue which comes before the investor the best prepared, and about which he knows the whole story as a result of advance preparation, gets the most favorable market. You should have someone to set up the bond issue, handle the legal matters, draw up prospectuses, work with the engineers, and even run a public relations campaign if it is needed—some one to "presell" the issue, who has access to, and the confidence of, the large buyers, who can help the dealers, and who knows markets. If the issuer could save only ⅛ per cent in the coupon rate on a very large issue by such a procedure, he would save milions in interest, which would buy a great deal of advice. If your organization had such a consultant on its staff, he could probably be "leased out" at a profit as new deals came along.

Water Works Supermarket

To go from fact to fancy for a moment, let us assume that a nice young couple, Mr. and Mrs. Smith, with two children, have just bought a new $40,000 up-to-the-minute home in one of our better suburban towns. Now this couple has never heard about water costs. They had always lived in a New York apartment where their water was thrown in with the rent. In going to market, this young wife cannot order just so many pounds of dinner. She has to specify meat, peas, potatoes, bread, milk, and so on. So, instead of letting the young husband order a lump sum of water to take care of their needs, let us invent a water department at city hall which has various divisions, like a supermarket.

Mr. Smith, the proud homeowner, is seated on his porch when a man approaches and introduces himself as head of the drinking water division of the water department. They discuss how much drinking water the Smith family will want, but who could estimate that? "How about this," suggests the man, "a blanket contract whereby you can all drink as much water as you wish? The cost—1 cent per day per person." Smith knows that at his office downtown they pay 80 cents per bottle for drinking water, which comes to 16 cents per gallon. At home he can drink a gallon a day, if he wants to, for only 1 cent. So he signs up with alacrity.

The next executive to call is the head of the personal health division, which provides water for bathtubs and washbasins. "I want plenty of that," says Smith. "A couple of times last summer, when we lived in that hot apartment, I told Mrs. Smith I'd gladly pay $10 for a nice swim."

"Is that so?" rejoined the man. "Why, that $10 would supply you with all the showerbath water you wanted for 500 days—over 1¼ years."

"No fooling," says Smith. "How much does this water cost?"

"Only 2 cents per day per person," says the man. Smith, knowing that you use heaps more water for bathing than you possibly could for drinking, and here it is only double the drinking water cost, promptly signs for that.

Then comes the head of the sanitary division. "You'll need water for your washing machine (about 40 gal per load), and the toilets (7–9 gal for each flushing), and the garbage disposal unit in the kitchen sink. It's cheap—same as the bathing water, in fact—only 2 cents per day per person. And remember, you might use more of this sanitary water than bathing water." Smith signs for that too.

The next man is from the miscellaneous water division. "Now," asks Smith, "just what is miscellaneous water and how much does that cost?"

"A cent a day per person," says the man, "and it includes a lot of things—rinsing the dishes, cleaning windows, washing screens and storm sashes, hosing the garage, washing the car, cooking, making lemonade, mixing drinks, bathing the dog, air conditioning—"

"Hold everything," interrupts Smith, "did you say air conditioning?" Well now, Smith has been bragging to his office associates how his new air-conditioning unit was going to be worth $50 a month extra during the hot summer weather. And here, for a few cents a day, he can virtually freeze himself into an ice cube if he wants to. So he buys that water too.

Before he gets a chance to relax, he sees the garden water superintendent admiring the new azaleas and other evergreens he has set out by his porch. This fellow assumes Smith wants garden water at 1 cent per day, but Smith, being only human, is hit by a sudden wave of economy and wonders how far this business is going. So, although he admits the price is cheap, he thinks maybe they will get along without it this year.

The disappointed superintendent starts for his car, and Smith, feeling a little proud of himself, saunters along with him. "Beautiful azaleas," says the superintendent.

"They should be," says Smith. "Cost me $36.50 apiece."

"Well," says the man, "I hope next summer's heat doesn't kill them, for they sure look nice." You can almost hear the adding machine in Smith's head clicking as he computes that water at 1 cent a day for 10 years would equal the cost of only one azalea, and here he has a dozen of them. He quickly "eats crow" and buys that service also.

Smith is not through yet. The head of the hydrant water division stops by. "This water is only in case of fire," he explains.

"How much does it cost?" asks Smith.

"Five dollars per person," he is told.

"Per day?" almost screams Smith, now a little frustrated.

"Oh no," says the man, "$5 per year."

"That's better," replies Smith, "but it seems too high to me."

"Not so high," answers the man. "I understand you have $30,000 fire insurance on your home and $10,000 on your furnishings. That means you pay $64 yearly for fire insurance. But, if you elect not to subscribe for hydrant water, your home would be classified as 'unprotected' and the rate would jump from 16 cents per $100 to 48 cents, which means you would be pay-

ing $128 extra each year on your insurance." Well, you know the answer. To save that $128 Smith invested $20 in hydrant water.

How silly can we be? And yet it could happen, and maybe it should. Smith has signed up, at prices which were proved cheap, for:

Drinking water	$3.65
Bathing water	7.30
Sanitary water	7.30
Miscellaneous water	3.65
Garden water	3.65
Hydrant water	5.00

a total of $30.55 per person per year. With four in the family, his annual water bill would be $122.20.

When I compare that with my water bill, I admit it sounds high. But take a quick look at our other utilities. I would guess that gas and electric charges in the average home come to $10 per month, provided you do not use electric heaters in winter or heat your hot water with gas. That totals $120 a year. Telephone service reaches a comparable figure. I cannot for the life of me see why water, with its multiple uses, is not worth as much as either of those two utilities.

Bulk Shipment of Fluorides

On Mar. 6, 1953, it became permissible for railroads to bulk ship sodium fluoride and sodium silicofluoride in covered hopper-bottom cars. The Interstate Commerce Commission's Classification Committee also authorized a minimum weight of 50,000 lb per car.

This decision is published as Supplement 10 to Uniform Freight Classification 1, and as Supplement 22 to Consolidated Freight Classification 20. For quick reference in discussing bulk shipment with freight agents, refer to Item 11535-A of Supplement 10 for sodium fluoride and to Item 11665-A of Supplement 10 for sodium silicofluoride.

Bulk shipments are available to all manufacturers. Because this is a new method of shipment for the chemicals, it is advisable to discuss the matter with the manufacturer in advance if bulk shipment is desired.

Management of Municipal Water Utilities

By John C. Doerfer

A paper presented on Sept. 18, 1952, at the Wisconsin Section Meeting, Madison, Wis., by John C. Doerfer, Chairman, Wisconsin Public Service Commission, Madison, Wis.

WEBSTER defines management as the "act or art of managing; the manner of treating, directing, carrying on, or using, for a purpose; conduct; control." Note that managing can be either an *act* or an *art*.

"Never assume the responsibility for conducting an operation, unless you can control it" was part of the advice given by a hard-bitten, old, experienced business executive to a class of college students of business administration. "And, if you have control, then you are to be held fully responsible," he added.

But times have changed. He was talking about the act of management. Today, the bargaining power of labor and the edicts of the federal government on prices, taxes, materials, and business practices have diluted some of the control powers available to management.

Skilled and successful management today rests primarily upon the art of dealing with those people whose powers affect policies. Technical skill, particularly in a water utility, is essential, but emphasis must be placed on the knack of dealing with government employees on all levels, as well as with customers and taxpayers.

This statement applies as much to the management of publicly owned municipal utilities as to that of private enterprise. Indeed, municipal public utility management may call for greater skill and art. In this field, the customers and the "stockholders" or owners are, for the most part, identical.

The first thing a person who is asked to manage a municipal water utility should ascertain is the overall objective of the municipality and, next, the extent of the powers of management. This, in turn, requires an understanding of the powers and objectives of the municipality itself.

Restrictions of Power

Municipalities are a branch of the state government. The state often enlarges, restricts, or reassigns municipal powers or functions in various forms.

At present the control of local public affairs is in part carried out by municipal corporations known as cities, villages, towns, or districts. Municipal departments, such as boards or commissions, with certain prescribed powers within municipalities, have been created, but generally these are not municipal corporations. A court decision (*1*) stated:

> Those who seek to support the bond issue . . . seem to think of the utility as if it were an entity existing separate from the city. It is like the city hall, the sewer system, and equipment owned by the city —merely a part of the city property. The fact that the plant is designated a "public utility" and the city required to set it up on its books as a separate operation does not incorporate it. The bonds, if issued, will be executed by the city, not by the "utility."

Municipal boards and commissions may come into being by state legislative action or by the exercise of municipal powers delegated to a local governing body.

A local municipal water utility in Wisconsin today is in reality a department of the municipality. But not even the municipality has absolute control over all utility functions. A large and important part of such utility functions has been reserved for state regulation through the Wisconsin Public Service Commission. This commission regulates certain aspects of construction, rates, and service. It has, however, no regulatory powers over municipal financing.

It has been the policy of the state to assign the operational and financial functions to the local municipality or to a board or commission created by the municipality. Section 66.068 of Wisconsin statutes reads, in part:

> 1. In cities owning a public utility, the council shall, and in towns and villages owning a public utility the board may, provide for a nonpartisan management thereof, and create for each or all such utilities a board of three or five or seven commissioners, to take entire charge and management of such utility, to appoint a manager and fix his compensation, and to supervise the operation of the utility *under the general control and supervision of the board or council. . . .**
>
> 7. In cities of the third or fourth class the council may provide for the operation of a public utility or utilities by the board of public works or by another officer or officers, in lieu of the commission above provided for.

The important point to remember is that the local municipality, having the power to create the instrument through which its proprietary functions will be exercised, retains supervisory and control powers. It can initiate or change utility policies.

It is also the settled law in Wisconsin that a municipality owning and operating a utility does so in its proprietary capacity. As such, it is subject to the jurisdiction of the public service commission to the same extent as a privately owned public utility (*2*).

The prospective municipal public utility manager or commission member who has studied and knows the extent of the local and state powers over the utility—or, to put it another way, the limitation of the local municipal utility commission's powers—may well decline the proffered job. He may subscribe to the theory that because he does not have absolute control over such fundamentals as long-term policies on construction, rate making, and financing, he does not wish to assume the responsibilities thereof.

Functions of Boards

At this point, however, he cannot help but be a little bit curious. What did the state have in mind when it boldly started out by ordering cities having public utilities to appoint a nonpartisan board and enumerating the board's powers, then made it subject to the general control and supervision of the local governing body and the state public service commission? Why did the state retain regulatory control over rates, construction, and service?

Undoubtedly the state had a combination of motives. There was a realization that the members of local governing bodies are frequently replaced. The conduct of a proprietary business requires specialized knowledge, stability, and experience. Too frequently the elected officials had insufficient time, knowledge, experience, or inclination to administer and manage a

* Author's italics.

municipal utility. No doubt, on some occasions, utility affairs were run not on basic business principles, but with ulterior motives more than tinged by political expediency. But, for the most part, a large number of persons familiar with the workings of a local government, including the elected officials thereof, were anxious to rid themselves of the tedious details; they realized the merit in having continuity in the personnel operating their utilities; they wanted experience; they wanted intelligent advice and informed opinions on the long-term needs of the utility; and they were equally anxious to provide some insulation against rank political or well-intentioned but inept meddling with the overall administration of a vital utility service. And yet there was apparently a desire by serious students of government to cling to a fundamental principle of local government—the retention of direct responsibility to the people by those who were given the power to tax and to spend.

Departments such as boards and commissions, which would spend allotted funds and implement local municipal policies, were to be created by appointment and not by election, with very few exceptions. When appointed, the members of such boards or commissions were to be directly responsible to the appointing power. Boards or commissions were to be primarily of an administrative character, as distinguished from policy-making bodies. Students of government recognize and accept the principle that the electorate could not and would not familiarize itself sufficiently with the technical and detailed duties of these bodies to make intelligent choices at the polls. The electorate did not, however, relinquish the right to hold someone responsible for the money spent by such departments, boards, or commissions. Accordingly, the members of local governing bodies were to be held responsible to the taxpayers. This accounts for the qualifying language in the statutes quoted which assigns to the members of the local governing bodies general supervision and control over nonelective boards and commissions.

The Wisconsin Supreme Court has commented (*3*) upon the legislative intent in establishing boards:

> No doubt it was the legislative thought that there would be helpful cooperation between the common council and the board of education. This is a commendable policy and should obtain. The common council should not arbitrarily or unreasonably embarrass the board of education in promoting the cause of education. The board of education is dealing with a special subject. It is necessary for it to visualize the future educational necessities of the city and to plan to meet such necessities. On the other hand, the common council is the fiscal authority of the city. It knows and understands the financial conditions of the city and the general municipal problems imposing burdens upon the taxpayers. Exorbitant demands of the board of education might very well make it impossible to carry forward other municipal undertakings of the greatest importance. There is sound policy in centralizing the taxing authority where a proper balance and proportion may be fixed and maintained in the matter of tax levies for all municipal purposes.

There is nothing inherently wrong with this principle. Frequently, however, the members of a governing body fail to understand the full significance of the phrase "general supervision and control." Sometimes they are inclined to become involved in details. If such a practice continues, it may be advisable to suggest to the local governing body that it review the line of demarcation between general supervisory

controls and the operational functions of the utility. The local governing body should apprise the utility boards of the broad policies which it expects them to pursue and should not attempt to meddle in every little detail as though it had completely forgotten its original purpose in creating the utility board or commission. On the other hand, as will be pointed out later, the managers of utilities cannot close their eyes completely to overall city problems.

Need for Financial Perspective

In order to conduct an economical financing program upon a sound business basis, it is essential that both the members of the governing body and the members of the utility board or commission understand the present and future capital expenditure program of the municipality.

A utility manager should not have too much difficulty in determining the amount of money that will be required to maintain, repair, or replace the facilities necessary to continue present service. The real difficulties appear, however, in properly planning expansions for future increases in demand. This suggests that, at the very outset, it is impossible to submit an intelligent financing program without ascertaining from the governing fathers what their plans are for the city as a whole. Accordingly, a utility manager should familiarize himself thoroughly with the overall plans of the municipality.

Managers should take an active interest in municipal planning. It may be that no one in the local government has any definite ideas. The utility manager should then take the initiative and urge the governing body to reduce to written form the long-term municipal program which has been planned, discussed, or contemplated. Various department heads should submit their present and long-term estimates of needed capital expenditures and the incidental increase in costs of operation. The members of the governing body should then be urged to apply a priority rating to the various projects. They should ascertain the approximate costs and designate the years within which such plans will be expected to materialize.

In addition, the members of the governing body should also indicate to the department heads what their own plans or policies are with respect to extension of the municipal boundary lines. Large or even small annexation programs are very important considerations in overall city planning, and all of their implications must be taken into account. The members of the governing body should be urged to adopt a resolution expressing its policies on a long-term program. The resolution is not binding but it would indicate to all the department heads, as well as the citizens and subsequent new members of the governing body, what the present and future problems of the municipality appear to be.

With the tentative future plans of the governing body on record, the various department heads, including the utility manager, can then submit a capital expenditure budget. Such long-term programs cannot, of course, be regarded as definite commitments, but they provide a starting point. From time to time revisions may be necessary. Nonetheless, such a charting will undoubtedly reveal definite needs and priorities which will aid the utility manager in submitting a definite and intelligent capital expenditure budget. When the members of the governing body and the members of the

various departments, including the utility board or commission, formalize and understand present and future municipal planning, a large barrier to the full and complete cooperation of all concerned will have been removed.

In addition, the utility manager should indicate his willingness to participate in such citywide economy measures as a central purchasing body for the acquisition of a common stockpile of supplies and equipment; to borrow or interchange municipal equipment whenever practical; and to comply with a citywide classification of employees and services so that like services receive like compensation and benefits regardless of the department in which the employee may be engaged.

With such a display of thorough knowledge of the municipality's problems and an attitude of full cooperation, it should not be difficult to receive in return the full cooperation and confidence of the governing body. The problem of financing should then become a relatively simple matter.

Methods of Financing

Municipal projects may be financed from revenues, reserve funds, special assessments, and revenue, mortgage, and general-obligation bonds. Unlike a private business, a municipality or any of its subdivisions must follow statutory authority for municipal financing or borrowing of funds.

Wisconsin statutes provide for the proportion of revenues which shall be necessary for: [1] reasonable and proper operation and maintenance of the utility; [2] a proper and adequate depreciation fund; [3] payments of the principal and interest of authorized bonds; [4] local and school tax equivalents; [5] additions and improvements; and [6] other necessary disbursements and indebtedness. Obviously, revenues must be sufficient to meet these requirements as well as provide an adequate return upon the capital invested. Adequate return includes principal and interest requirements. If, after reasonably efficient and prudent management, revenues are not adequate or sufficient to meet these requirements, application for a rate increase should be made to the public service commission. It is the duty of the commission to grant increases where the facts warrant it in accordance with the applicable law.

Replacement of equipment and facilities which have become worn out or obsolete is intended to be paid for from funds accumulated in depreciation reserves. If these reserves are inadequate, as often happens during inflationary times, and the net profit is also inadequate or is paid over to the municipality, then obviously the municipality must supply the money, either out of its general fund or by borrowing it. If a municipal long-term program has been adopted or is being planned, some provision should be included whereby the utility will be permitted to draw from an adequate fund specifically designated and allocated for such contingencies. This fund could be made up of a reasonable amount of prior net earnings. If no such fund has been accumulated, a start should be made and accumulations continued. By so doing, the municipality does not suffer a loss. Rather it is a reinvestment at a higher price level in capital assets which will be allowed by the public service commission to earn a reasonable return, to the ultimate benefit of the municipality.

The statutes provide that any municipality which owns or operates any public utility may, by action of its gov-

erning body, issue revenue bonds to pay the cost of purchasing, extending, improving, or operating a public utility. Although this form of financing is designed generally to raise funds for capital additions and extensions, it can be used for the replacement of facilities at higher price levels. Because it has no "open end" provision, however, it should be used sparingly. If in the future a need for additional revenue bond financing for large extensions or improvements arises, prior revenue bonds then outstanding, even if small in amount or in relation to revenue, may have to be refunded, thus increasing or duplicating the cost of financing.

Neither revenue bonds nor mortgage bonds for utility purposes are to be considered a debt of the municipality. They are not to be included in arriving at the constitutional 5 per cent debt limitation.

Special assessments are designed primarily to assess abutting property owners for the benefits accruing to them from the installation of water mains. The applicable statute deals with contractors' certificates as liens against specific parcels of real estate and with special assessment bonds.

Mortgage bonds or certificates constitute a debt of the utility which is secured by its facilities. Upon default, the utility or that portion mortgaged can be foreclosed and acquired by the mortgagee.

General-obligation bonds are a form of financing in which the city lends its credit. These bonds can be liquidated by special assessments payable in installments. Such bonds are subject to the 5 per cent constitutional debt limitation. If a municipality concludes that it has no large long-term program calling for extensive expenditures to be amortized over a period of years, or has sufficient margin in its constitutional debt limitation, it may use its general credit for financing all or part of the capital needs of a water utility. One advantage of this type of financing is that such obligations generally can be issued at a lower interest rate than some of the other types of securities.

The various methods of financing are grounded upon some statutory authority. Legal advice should be obtained and followed.

Conclusion

Essentially, the successful management of a utility is more of an art of getting along with people in and out of government than it is the cold, impersonal act of directing the operations of a utility. Frequently utility managers and other department heads become impatient with what they deem an inefficient administration of local affairs. They should remember, however, that the local governing bodies have the big job of correlating all the various demands of the entire municipality. Different departments may be working at cross-purposes with each other, and these conflicts must be reconciled, sometimes in a more or less arbitrary manner. A democratic form of government is not the most efficient type but it is the most satisfactory in the long run. Impatience has no place in the art of management.

References

1. *Roberts* v. *Madison*, 250 Wis. 317 (1946).
2. *Pabst* case, 190 Wis. 349 (1926).
3. *State* ex rel. *Board of Education* v. *Racine*, 205 Wis. 389 (1931).

Natural-Fluoride Well Water Added to Portsmouth Surface Supply

By X. D. Murden

A contribution to the Journal by X. D. Murden, Supt. Portsmouth Water Dept., Portsmouth, Va.

THE Portsmouth, Va., Water Dept. serves consumers in Portsmouth and Suffolk, as well as parts of Norfolk and Nansemond counties. While the department was in the process of planning to fluoridate its surface supply, in accordance with resolutions passed by the governing bodies of these four political subdivisions, a well which had just been dug in the watershed area was found to contain 5 ppm fluoride. A check of other wells in the vicinity showed a comparable fluoride content. The department thereupon had a well drilled near its Lake Kilby filtration plant to supply 2.5 mgd of water containing 5 ppm fluoride. This water is mixed with the filter effluent to provide the desired fluoride content in the water delivered to the distribution system.

The installation cost $30,000, which is more than the price of chemical-feeding equipment. This difference will be made up in less than 2 years, however, because the operating cost is only approximately one-third that for filtered lake water. The fact that no fluoride need be purchased will, of course, result in further savings.

In addition to providing a financial advantage, the installation will also be of great value in overcoming a water shortage during the summer months. The well now furnishes approximately 25 per cent of the water supply for the Portsmouth Water Dept. This has made it possible to postpone for 2 years the construction of a new dam to increase storage capacity sufficiently to meet present needs. When the dam is finally built, the reduction in its cost will far exceed the cost of the well.

The installation is, therefore, more than justified economically. Also, the public reaction has been excellent, for Portsmouth is not adding fluoride but merely good water.

Impact of Municipal Water Fluoridation on the Food and Beverage Industries

By George S. Bratton

A paper presented as part of a panel discussion on fluoridation on Sept. 23, 1952, at the Missouri Section Meeting, Jefferson City, Mo., by George S. Bratton, Tech. Advisor, Anheuser-Busch, Inc., St. Louis, Mo.

DURING the past 50 years great strides have been made in the fortification of our food and beverage supplies with the essential mineral elements and vitamins that these products need for adequate human and animal diets. During this 50-year period science has revealed not only the cause but, more important, the cure for most of our dietary deficiency diseases. Many of you can remember when it was discovered that the irradiation with ultraviolet light of many foods and beverages that contained ergosterol produced Vitamin D, known as the sunshine vitamin. Your children are doubtless drinking irradiated milk to supply Vitamin D essential for the proper bone structure.

You perhaps are also familiar with the progress that has been made in the restoration or enrichment of our food supplies with the water-soluble vitamins, such as thiamin, riboflavin, niacin, pantothenic acid, biotin, and, more recently, Vitamin B–12.

You are all well aware of the enrichment of bread by the baking industry, the enrichment of flour for home baking, and the enrichment of cornmeal and other cereals with those vitamins and minerals removed in milling. We and our children no longer fear the scourge of scurvy, beriberi, and other malnutrition diseases that were so common in the past.

This brief mention of the progress of the past half century in the restoration of the vitamins and minerals essential to our diet has been made to emphasize one point: heretofore, recognized vitamin and mineral deficiencies have been supplied through the food and beverage channels throughout the nation by private enterprise without incurring the criticism of many people against forced mass medication.

In the category of trace-element dietary needs, at least for children, in many areas of the United States, fluorine may be included because of its beneficial effects on tooth formation and structure. Although many of our citizens, including many reputable scientists, oppose fluorine therapy for various reasons, the author's opposition is not against the use of fluorine when and where needed. But he is sincerely opposed to the use of municipal water supplies as the carrier for this or any other dietary element needed in human or animal diets. This is a form of forced mass medication,

the results of which have not yet been fully evaluated.

The fluoridation of municipal waters as a means of reducing the incidence of caries or tooth decay has, in the author's opinion, the following objections:

1. The fluoridation of municipal water supplies necessitates the use of fluoridated water for a multitude of industrial and domestic purposes where it is not needed and in some instances is actually harmful. There has not yet been sufficient or conclusive research evidence on the total effect of fluoride upon people of all types, ages, and varying degrees of health. This is amply brought out in the Delaney Committee report, made on July 10, 1952, to the U.S. House of Representatives, on the subject of "Fluoridation of Public Drinking Water."

2. Only a very minute fraction of the municipal water supplies are used for drinking purposes.

3. Municipal water is available to only approximately two-thirds of the population of our country.

As the author has been invited to discuss the use of fluoridated water by the food and beverage industries, the following comments will be confined to that group of industrial water users. (Parenthetically, the author wishes to state again that he does not oppose the use of fluorides for children in the prevention of caries.)

Obviously, the purpose of fluoridation is to get fluorine to those who would benefit by it, but, just as obviously, it is necessary to keep it away from the people who do not need it or who would be actually harmed by it.

The use of fluoridated water by the food and beverage industries imposes on them many difficult problems which have already begun to show up in initial research and which will become more difficult to solve as more municipal water supplies are fluoridated. This is particularly true in the larger industrial centers where the bulk of food and beverage products are processed. There is very little actual long-term experience with fluoridated water in the large industrial cities. The problems of the food and beverage industries might be grouped into two classes: [1] those that have to do with the processing itself where fluorine interferes with the normal procedure of operation, such as in the microbiological and enzymatic processes about which more will be mentioned later; and [2] the problems of complying with the food and drug regulations where the residual fluoride is above the allowable limits.

Wet-milled Corn

Some specific instances will illustrate problems involved. The wet-milling industry grinds corn by a wet process after it has been steeped in water. In the process, it separates the corn kernel into its different fractions, including corn solubles, corn oil, gluten feed, starches, dextrines, and corn syrups. In the Kansas City and St. Louis, Mo., areas, more than 20 mil bu of corn is processed annually by the wet-milling procedure. In the United States, more than 125 mil bu of corn is milled annually by this process. This industry uses tremendous quantities of water.

In the wet-milling process, corn is first steeped in tanks of water containing a small amount of sulfurous acid. During the steeping process a bacterial fermentation is carried on to convert the extractable sugar into lactic acid.

After steeping, this water containing the corn solubles is evaporated in multiple-effect evaporators to a heavy syrup. The heavy steep water is used by the pharmaceutical industry to propagate microorganisms that produce antibiotic compounds, such as penicillin. It is also used in baker's yeast production, as well as in animal and poultry feeds. It is one of the richest sources of inositol, now finding increased use in the pharmaceutical field.

After the corn solubles are removed, the wet-milling process is carried on to separate the germ and oil, as well as to separate the gluten from the starch. The starch fraction is filtered and dried or converted to a dry dextrine, or the starch slurry is cooked under pressure with acid to convert it to a syrup, out of which are produced various edible syrups, as well as dextrose sugar. Corn syrups are used almost exclusively for human food, in table syrup, candy, ice cream, jelly, jams, bakery goods, and other types of sweetened foods.

If the wet milling of corn is carried on with fluoridated water (1 ppm), it is estimated that the concentrated steep water would contain more than 6 ppm of fluorine and the corn syrup, more than 5 ppm. The starches, dextrines, oil, and feeds would contain less.

When John L. Thurston, Acting Administrator, Federal Food and Drug Administration, issued a statement on July 17, 1952, that the administration would not prosecute food and beverage manufacturers for shipping interstate products made with municipal fluoridated water "unless the process involves a significant concentration of fluorine from the water," he did not make the wet corn millers feel very cheerful. The author also knows that the malt syrup manufacturers are just as unhappy over their fate, because malt syrup made with fluoridated water may contain up to 8 ppm fluorine.

Yeast

More than 250 mil lb of baker's yeast is produced annually in the United States. To produce this amount of yeast requires more water than all the children of the United States drink annually.

Yeast culturing is a type of aquatic farming. Yeast is a plant, microscopic in size, that must be grown in water; it must be harvested in water, and it must be put back in water at the bakery to carry on the dough fermentation. Water is critical to its existence. Experts in fermentation have long recognized that some natural waters were better than others where yeast is involved. That explains, in part, why those beverage industries that use yeast are largely segregated in certain areas and likewise avoid other areas. Kentucky, for instance, had something very real to offer to the distilling industry.

Cultured yeast requires a very carefully regulated diet. Included in its diet must be all the necessary trace elements in the right amounts. Among these trace elements needed for yeast nutrition are iron, copper, zinc, manganese, and, possibly, cobalt.

In this connection, it seems appropriate to relate an experience which the author had many years ago at the Anheuser-Busch baker's yeast plant in St. Louis. This plant regularly used St. Louis city water, although it has a large water works installation of its own, which is used for the power plant

and for cooling water for various operations. The company's water plant has its raw-water intake in the Mississippi River at the foot of Arsenal Street in St. Louis. The procedure of purification and filtration of water is similar to that used by the city, and the laboratory control over the operation would meet the state standards for potable water. At one time the company wanted to use water from its own plant for baker's yeast production. Of the many large-scale pilot runs with this water, most were satisfactory, but a few of them were totally unsatisfactory. Strangely, in those that were unsatisfactory, the yeast would apparently grow perfectly normally until it was almost ready to harvest. Then, suddenly, it would lose its baking strength almost completely, although, by every other laboratory test, the yeast was healthy. It was found that these bad lots of yeast were apparently deficient in copper, but that was not the whole trouble.

The company finally abandoned the plan completely because of the fact that it had never had that trouble with St. Louis city water or at the New Jersey yeast plant. The cause of the difficulty still is a mystery, but it will be appreciated how concerned the company is whenever the question of water for yeast growth is raised.

The author does not know just what effect additional fluoride would have on baker's yeast culture, but he does know that no yeast manufacturer in America is deliberately adding a fluoride to his process water today. In order to secure more accurate information on this question, the Brewing Industries Research Institute is sponsoring an investigation now being carried on by the eminent scientist, Morris Moore, at Barnard Free Skin and Cancer Hospital in St. Louis. His work is not yet far enough along to make public but the author has permission to mention one fact that might be pertinent to water fluoridation. Moore's tests show that sodium silicofluoride is more toxic to yeast than sodium fluoride. The author cannot escape concern over the possibility that this observation may hold true for other forms of life. So far as he knows, the choice of fluorides for municipal water fluoridation has been determined entirely by economic or engineering reasons.

Yeast is also used in very substantial quantities by the pharmaceutical and baby food manufacturers in this country. One of the largest of these has definite specifications on the maximum allowable fluorine in the yeast it purchases. Yeast as produced in nonfluoridated water meets those specifications, but, according to the author's laboratory findings, if fluoridated water is used in yeast culturing, the yeast will have more fluorine in it than is allowable by this one manufacturer. As a matter of interest, it might be mentioned that this baby food manufacturer uses bonemeal as one of the ingredients. Only bone from veal is acceptable, because the fluoride content of the bones of older animals is too high. These instances illustrate the complexity of the problems connected with the use of fluoridated water and also serve to emphasize the need for more time to try to find a workable solution.

Conclusion

Drinking water is a very minute fraction of the total water the municipal water plant must process. The food and beverage industries are very large users. If St. Louis should fluo-

ridate its water supply, the food and beverage industries in that city would, the author estimates, be shipping out of St. Louis at least 30 times as much fluorine in the products these industries sell in interstate commerce as all the children of St. Louis use for drinking purposes. These products are distributed all over the United States, including areas that now have fluoridated water. Much of this output goes to adults, much of it to pharmaceutical and medicinal channels for people who are under medical care. It is obvious that the fluoridation of the municipal water supply in communities where food, beverage, pharmaceutical, and medicinal products are manufactured and shipped outside the city can get completely out of bounds.

Presumably, the city government in a community that fluoridates its water would not be held responsible for the fluoride content in the food, beverage, and medicinal products made from that water. The manufacturer alone, as the author understands it, must bear the responsibility for the residual fluorine in his products. The manufacturer must meet Federal Food and Drug Administration standards. He must fulfill the demands of his customers and meet the competition of manufacturers who are not using fluoridated water.

The author knows that many of you feel municipal water is still not the most satisfactory carrier of fluorides for children's teeth. Many of you are opposed to this plan from a purely engineering point of view. You rebel at the thought of using tons of fluoride for a job where pounds are all that is needed. Many of you want to know why more research is not being done in evaluating other compounds of fluorine and evaluating other methods of fluorine medication. You are all aware that our approach to such a basic scientific problem has unfortunately gotten involved into too many ramifications outside the field of science and medicine to arrive at an answer free of prejudices.

It is refreshing to read, in such times as these, the reports that were issued in 1952 by the Missouri Water and Sewerage Conference concerning the "Fluoridation of Public Water Supplies." According to the statistics furnished to the fluoridation committee of the Missouri Water and Sewerage Conference by the Dental Section, Missouri Div. of Health, and published in Circular Letter No. 2, Apr. 16, 1952, the children who live along the Missouri River, including St. Louis, have a dental-caries record that must be the envy of every community now fluoridating its water supply.

In the light of these statistics, it seems to the author that the citizens of Missouri, especially in the larger centers, can well afford to wait a little longer before embarking upon the fluoridation of their communal waters as the solution to better teeth for their children.

Considerations in Supplying Fluoridated Water to Industry

By W. Victor Weir

A contribution to the Journal by W. Victor Weir, Pres., St. Louis County Water Co., University City, Mo.

THE growing practice of fluoridation of public water supplies has brought problems to the water utilities and to some of their customers. These problems exist principally where fluoridation is being considered. To a lesser extent, they exist where fluoridation is being practiced. Oddly, such problems seem rarely to be found where water supplies have carried 1.0–1.5 ppm F for many years.

This discussion cannot cover all the questions which have been raised. No water works man, including the author, is qualified to discuss all the dental, medical, public health, commercial, and industrial problems involved, or which are purported to be involved.

Concerning the categories of dentistry and medicine, the water works man can, at best, be an informed layman. In the many statements which have been made on the benefits or hazards of fluoridation, he can try to separate the grain from the chaff, for his own information, but not to make himself an expert.

The public health field is, however, not far removed from the water supply field. Many water supply operations have public health aspects. Consequently, many persons in the water supply field are familiar with the techniques of epidemiology and vital statistics, particularly when they involve water supply.

Several statements have been made that fluoridation of public water supplies may produce long-term detrimental effects on human beings in the form of cancer, heart trouble, kidney disorders, and so forth. Such statements are important to water works men, not only to those considering or practicing fluoridation, but also to those connected with the many supplies which have had fluoride-bearing water for many years. If fluorides in the water supply are detrimental when equal to or more than the amounts recommended by the dentists (0.7–1.5 ppm F), that fact should readily appear in studies of vital statistics. More than 3,000,000 people have had such fluoride-bearing water for many years. Typical cities are Green Bay, Wis.; Aurora, Galesburg, and Monmouth, Ill.; and Colorado Springs, Colo. More than half of Denver, Colo., has received such water since 1938. Prior to 1938 the entire city received water containing 0.9–1.0 ppm F.

The vital statistics of these cities, when compared with those for cities using low-fluoride or fluoride-free water, indicate no significant difference in incidence of disease or deaths from cancer, heart trouble, and kidney and

other disorders which at times have been attributed to fluorides. Although some persons who debate the subject rigorously overlook existing vital statistics, the facts appear to be all the other way. The evidence is that water supplies containing 0.7–1.5 ppm F are satisfactory from a public health standpoint. This fact is important.

Very little has appeared concerning adverse effects of controlled fluoridation of public water supplies upon industrial processes. The cracking of artificial ice at Charlotte, N.C., was reported, together with the easy method of correcting the difficulty (*1*). The water works industry has heard that studies have been and are being made by various industries on the possible problems they might have if their supplies were fluoridated. These investigations are important to the public water supply industry, which has no desire to alienate a substantial body of its customers by adopting a treatment process that will cause them to turn to other sources.

Bratton has outlined some of these industrial problems (*this issue*, p. 364). His suggestion that fluoride-bearing water is unsuited for a series of water-using industrial processes should cause us to put in order our thinking about the functions of a public water supply in a community.

Water Quality

Municipal water systems came into being as people developed compact groupings where the need for domestic water supplies outgrew the ability of the closely built area to supply them individually. Parallel with the need for domestic water supply was the need for water to fight fires. Today, as small towns never before provided with a public supply build water systems, the value of the supply for domestic needs is supplemented by the saving in insurance rates. As knowledge of the need for safe water for domestic use has increased, the procedures necessary to make the supply safe and palatable have required the expenditure of large sums which did not improve the water for fighting fires. Likewise, many small commercial and industrial units which are customers of municipal systems do not require bacteriological safety of a water for the uses they make of it. In fact, it is well known that some of the modern water treatments, such as those involving the addition of alum, ammonia, chlorine, lime, and phosphates, may make a water supply less desirable for certain industrial uses than if these treatments were not applied.

Correlatively, it has long been understood that certain water-using process industries require that water be conditioned far beyond the extent needed for the domestic users' safety and comfort. Quite a few years ago an industrial water user in metropolitan New York brought legal action to compel the city to deliver to his plant a supply precisely adjusted to his needs for water quality. The court decided that, so long as the supply was suited to the needs of the domestic consumer and otherwise available in adequate amounts, it did not have to be tailored to suit the widely varying requirements of industrial users (*2*).

The average water works prides itself on its ability to serve the needs of industry, but many water works have found themselves unable to produce for industry the amount of water wanted at a price the industrial user was willing to pay.

There are a substantial number of industrial water users whose quantitative requirements are so large and whose quality requirements are so minor that the public systems do not serve them. Steel, oil refining, and paper making are a few examples of those industrial operations which require so great an amount of water that the operators choose to install works to meet their needs.

The total amount of industry-produced water used daily in the United States is almost double the daily total supplied by public water systems. This condition does not exist because public systems could not meet those needs if they had a monopoly on water supply. It results from the deliberate choice of many industries to provide for themselves the kind of water they want to use at less cost, in their opinion, than if the public systems supplied them.

On the other hand, fluoridation may produce problems for a manufacturer who has come to rely upon a public water supply low in fluorides and has made a considerable investment in his plant. If the manufactured products should become unacceptable owing to concentration of fluorides, that manufacturer might suffer injury unless he could obtain another water source or find a way to remove the fluorides easily. The water utility and the community have a responsibility to such a customer, if the injury is material. Such problems will necessarily be local rather than general, however, as food processers that concentrate the minerals found in public water supplies are exceptions rather than the rule.

A water utility has a definite interest in seeing that equity prevails when a change in water treatment may be beneficial to one class of consumers but detrimental to another. The solution of such a problem may be beyond the responsibility of the water department or company, but the utility can help in assessing the factors involved in the problem.

TABLE 1

Water Supply Sources of Corn-grinding Mills

Location of Mill	Private Well Supply	Private Surface Supply	Public Water Supply
Illinois			
Argo	√ *	√	√
Decatur		√	
Granite City	√		
Pekin	√		
Indiana			
Indianapolis	√		
Roby	√		√ †
Iowa			
Cedar Rapids	√		
Clinton	√		
Keokuk		√	√ ‡
Missouri			
Kansas City	√		
St. Louis		√ §	√
Texas			
Corpus Christi	√		√

* Mill is equipped to use own wells, Chicago city supply, or own surface supply as elected.
† Public water supply use is very small.
‡ Mill operates own complete water treatment plant.
§ Modern water treatment plant is installed at mill, but not used in grinding.

Wet-milled Corn

Bratton records his apprehension that the wet corn millers will find themselves in difficulty from water supplies to which fluorides have been added. Reliable advice from a leader (*3*) in the corn products industry is that there are twelve large mills in the United States where wet-grinding of corn is done. These plants and the water supplies used or available to them are listed in Table 1.

It will be noted that each of these large corn-grinding plants has installed its own supply works. Anheuser-Busch elects to use the St. Louis public supply rather than the water from its own treatment plant. At Corpus Christi, Tex., current water shortages compel the mill to purchase part of its supply from the city. Three other mills have public supplies available but do not appear to use them in their grinding operations.

Assuming, however, that a wet-milling plant uses a fluoridated water supply, what ensues? R. E. Greenfield, Vice-Pres. in Charge of Manufacturing, A. E. Staley Manufacturing Co., Decatur, Ill., whose knowledge of public water supply problems goes back to the days when he was an associate of Edward Bartow in the Illinois State Water Survey, makes the following comments (*3*):

> In the process of milling corn by the bottling-up system, something over 5 gal of wash water per bushel of corn is used in washing the starch; and this eventually finds its way into the steep water, where it is concentrated down to a volume which is somewhat less than 1 gal. Furthermore, if all the steep water were used in corn gluten feed, the corn gluten feed might itself exceed 3 ppm of fluorine. This is assuming that fluorine is not absorbed in the solid parts of the corn, and carried out to some other outlet.
>
> [The fluorine] being a soluble material, we would have to assume, lacking experimental evidence, [that] it did concentrate in the steep water. Similar calculations would indicate a similar possibility of concentration of fluorine in corn syrup, although with our process, possibly not above 3–4 ppm.
>
> It is perfectly true that steep water made from a process using fluoridated water would probably not go above 4–5 ppm, and [in] the total corn feed from the plant, not above 3 ppm. It would seem, therefore, that these limits are safely below the maximums set by the control officials.
>
> Most feed mixtures carry minerals containing phosphates. Phosphates derived from natural sources other than bone are inclined to be high in fluorine.
>
> The Association of American Feed Control Officials has set [fluoride] limits which are pretty generally followed in a great many states. Their suggested limits are: feed for cattle, not over 0.009 per cent, which is 90 ppm; for sheep, not over 0.01 per cent, 100 ppm; and for swine, not over 0.014 per cent, 140 ppm. You see, therefore, that these limits have been fixed from 0.009 to 0.014 per cent fluorine.
>
> . . . most manufacturers . . . will accept mineral mixtures with 300–450 ppm of fluorine; . . . by the time they use this in their feed mixtures, it will be reduced to the 90–140 ppm above mentioned.

As feed producers will accept mineral mixtures containing 300–450 ppm F and set a tolerance limit of 90–140 ppm F for the final feed mixture, the possibility that the corn feed from a plant using fluoridated water will contain up to 3 ppm F cannot be considered a serious problem to the feed processer.

What is the significance of a possible fluoride content of 3, 4, or even 5 ppm in corn syrup? Fluorides are not strangers to our diet. Beef contains 2 ppm F, pork 1 ppm, and lamb 1.2 ppm. Among the fish foods, fresh mackerel contains more than 25 ppm F, canned salmon 9 ppm, and codfish 7 ppm. The average daily diet contains approximately 0.25 mg F in areas where the water is practically fluoride free (*4, 5*). Can one consider that the use of corn syrup containing 5 ppm F would make a significant addition to the normal diet? In areas

where there is stated to be a fluoride deficiency, the increased fluorine would seem to be a dietary improvement. In areas where drinking water would contain 1.0 ppm F, the ingestion of 1½ oz of corn syrup containing 5 ppm F would be the equivalent of drinking an extra glass of water. Three ounces of mackerel would provide as much fluorine as a pound of such corn syrup. If health authorities found corn syrup made with fluoridated water to be unacceptable, they would, to be consistent, also have to place a limit upon the quantity of water persons could drink or the amount of fish they could eat.

Yeast

Bratton possesses far more knowledge of the techniques of yeast production than does the present writer. Bratton refers to the known need for trace elements of "iron, copper, zinc, manganese, and, possibly, cobalt" in yeast nutrition. He mentions the fact that steep water derived from the wet milling of corn is used in baker's yeast production. He points out, as is well known in the corn products industry, that steep water is a rich mixture of the solubles in corn. But corn itself is fluorine-bearing, the dry grain carrying as much as 2 ppm F, cornmeal as much as 2 ppm, and corn germ 8–11 ppm. May it not be a fact that the fluorine in the corn kernel is taken up by the steep water in processing, so that the steep water may contain a measurable amount of fluorine even if the water was originally unfluoridated? This element in the situation will without doubt be carefully considered by Moore in his current investigation for the Brewing Industries Research Institute.

Some facts are known about certain industrial fermentation operations. In July 1950 the American Institute of Baking stated (*6*):

> The addition of fluoride ion in concentrations up to 10 ppm in the sponge and dough water has no effect upon bread quality. Bakers in communities that plan to incorporate fluorine in the city water supplies as part of a program to reduce the incidence of dental caries should anticipate no difficulties in using such water for bread production.

A survey of several cities where the natural fluoride content of the water was equal to or greater than the amount recommended by the dental profession, as well as those cities where a controlled fluoridation program was in effect, disclosed that in no location had the normal production of beer suffered adverse effects (*7*). These facts are professionally supported by R. R. Slater (*8*), of the Pabst Brewing Co., who states:

> When yeast encounters wort (unfermented malt) containing 1 ppm F, its metabolism is stimulated slightly. Five ppm F has a similar effect. Depending upon the source of the fluorine, 10 ppm may have a slightly stimulating or depressing action. At concentrations of 25 ppm or more, the fluorides are definite inhibitors of yeast activity.

Thus, it can be seen that fluorine, like other materials, has a variable effect upon enzyme or metabolic activity, depending upon the concentration. Slater's study clearly indicates that, at the concentrations of fluorine recommended for public water supply, the effects are stimulating to yeast activity. M. Starr Nichols of the Wisconsin State Health Dept. Laboratories has studied the fluoride accrual in yeast

from two breweries in that state. One brewery, which uses a water containing 1.6 ppm F naturally, produces a yeast which contains (dry) 24 ppm F. The beer produced with this water had a fluorine content of 0.7 ppm. The other brewery, using a supplemented water with a fluorine content of 1 ppm, operated with yeast which contained (dry) 20 ppm F. In both instances, the brewery operations were normal (*9*).

Food and Drug Administration Policy

The policies of the Federal Food and Drug Administration on the fluoridation of water supplies may best be appraised by quoting in its entirety the administration's information letter of June 3, 1952, which states (*10*):

> The program for fluoridation of the public water supplies, advocated by the Public Health Service of this [Federal Security] Agency, contemplates fluoridation at a level optimum for prevention of dental caries and without hazard from the fluorine to the consumers. The quantities of fluorine recommended to be added to water take into account the expectation that the total ingested water supply of the inhabitants of the areas which adopt fluoridation will be from the fluoridated public source. That is to say, the people will ingest not only the quantity of fluorides which would be taken in from the water employed as drinking water but also from the water employed in cooking in the home and in public eating places. It would, therefore, appear that when commercially processed foods which contain added water as one of the normal ingredients are employed in homes or in public eating places, in place of the same or similar articles of food which might be prepared in the home or in the restaurant, the fluorine intake of the populace should be the same whether the fluoridated water is added in a food factory or added in the home kitchen.
>
> On this basis, the use of fluoridated water in the manufacture of commercially processed foods should not increase the fluorine intake of persons dependent upon fluoridated public water supplies, nor adversely affect the benefits of the fluoridation program. This, of course, is a warranted conclusion only so long as there is no increase in the fluorine content of such processed foods by reason of concentration from the water, which may occur in some processes. We, therefore, have not felt that there should be any restrictions upon the use of fluoridated water in food processing where such use is not calculated to increase the overall fluorine intake as against the general use of fluoridated water supplies in the household as drinking water and for culinary use.
>
> It is unfortunate that rumors have been circulated implying that there is a conflict of views between this [Food and Drug] Administration and the Public Health Service authorities with regard to the fluoridation programs. Admittedly there may be aspects of the food and drug laws, designed to prevent the unwarranted and unnecessary addition of any toxic substance to foods, which require reevaluation and interpretation in the light of the developments of calculated fluoridation of the public water supply. We think there is reasonable agreement among experts as to the intake of fluorides which the human body can handle without adverse effects, and we shall continue to zealously exercise our functions of undertaking the prevention of sale or distribution of foods which are in fact unsafe, taking into account all of those facts and circumstances which have a bearing upon the question of safety.
>
> Naturally, when substantial portions of the population increase their fluorine intake by the amounts being added to the water supply, the total amount which it may reasonably be expected such people will ingest must be looked at by appro-

priate consideration of probable fluorine intake from all sources other than from the water supply. Sanity and reasonableness must prevail and we are prepared to deal with any specific problem on the basis of the peculiar facts of the case.

The water works industry appreciates the consideration given by Bratton to the fluoridation of public water supplies. The author cannot agree, however, that the apprehensions concerning adverse effects of controlled fluoridation upon the food and beverage industries are borne out by the presently available information.

The Federal Food and Drug Administration must, in its own words, see that "sanity and reasonableness" prevail in its "zealous" exercise of its functions of undertaking the prevention of the sale and distribution of unsafe foods. More and more fluoride-bearing foods and beverages will be shipped from community to community if the present trend toward fluoridation of water supplies continues. This situation cannot be prevented without denying the use of fluoridated water to many food and beverage processers. Whether the quantities of fluorine in the foods so shipped have any real significance must be assessed by the proper health authorities.

Whether future progressive adjustments must be made in the fluorine content of public water supplies will also have to be determined by the authorities responsible for controlling the total fluorine intake of the citizens of various communities.

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A Rational Approach to Fluoridation

By Jack E. McKee

A paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by Jack E. McKee, Assoc. Prof. of San. Eng., Civ. Eng. Dept., California Inst. of Technology, Pasadena, Calif.

MANY ideas and concepts that govern our actions, even in quasiscientific areas, are like Topsy in *Uncle Tom's Cabin*—nobody made them; they "just growed." Often such growth follows the course of least resistance and least mental exercise, for most of us are too busy or too involved in the complicated problems of our profession to challenge or question the thought processes and channels through which accepted concepts have developed. Occasionally, however, we must stop in the mad rush of progress, examine our position, retrace our steps if necessary, and see if we are truly on the right path. One such concept that deserves to be reexamined critically and analyzed on the basis of sound fundamental data is the fluoridation of municipal water supplies.

A true scientist must learn to strip a mass of accumulated ideas and figures to obtain fundamental data. He must be able to separate facts from fancy. With these facts as the foundation, he can proceed to develop hypotheses, to prove these hypotheses, and to build up a pyramid of sound data culminating in the apex of a logical conclusion. Such a rational approach to the subject of fluoridation of water for the inhibiting of dental caries has been long overdue. Let us attempt, therefore, to isolate from preconceived notions and the voluminous literature the fundamental facts about fluorides, and to use these data to develop a sound approach to the problem.

Fundamental Facts

1. Fluorine is a so-called "trace element" in human nutrition (*1*), but, in the accepted sense of the term, fluorine does not appear to be an "essential element"; that is, its removal from otherwise adequate diets does not produce fatal or disabling symptoms. According to McClure (*2*), "Dental caries cannot be classified as a fluorine-deficiency disease until it has been demonstrated that inadequate amounts of fluorine in the diet invariably produce the disease. Thus far, such observations have not been made."

2. Fluorine is present in most foods in concentrations varying from a trace to more than 10 ppm in several seafoods and to more than 100 ppm in many types of tea (*3*). The majority of foods, however, contain 0.2–0.3 ppm fluorine as consumed, and, hence, the average American diet, exclusive of drinking water, appears to provide 0.2–0.3 mg fluorine per day.

3. Fluorine is considered to be a highly toxic element, with doses of

250–450 mg giving severe symptoms and 4.0 g causing death. Although it is highly unlikely that critical or fatal doses will arise from food or drinking water, skeletal damage or the mottling of dental enamel may result from the consumption of fluoride-bearing water. A recent summary of numerous references (*4*) led to the generalization that water containing less than 0.9–1.0 ppm of fluoride seldom causes mottled enamel in children, and, for adults, concentrations of less than 3–4 ppm are not likely to cause endemic cumulative fluorosis and skeletal effects. In other terms, a child can tolerate a steady dose of approximately 1.0 mg of fluoride a day and an adult, approximately 4 mg per day.

4. In concentrations less than the threshold values given above—that is, less than 1.0 ppm in drinking water for children—assimilable fluorine or inorganic fluoride in drinking water appears to have an inhibiting effect on the frequency of dental caries. Within certain limits there is an inverse relationship between the fluoride content of drinking water and the DMF (decayed, missing, and filled) rate in children dependent upon these supplies (*5*). Children reared in cities where drinking water contained approximately 1.0 ppm fluoride experienced only approximately one-third as many dental caries as those who resided in communities with water supplies free of fluorides (*6*). This effect of fluorides upon the DMF rate is not a straight-line relationship, however, for most of the improvement occurs with the first 0.5 ppm of fluoride in the drinking water. Svore and Williamson (*7*) report that the relationship appears to be a curvilinear function typical of a first-order reaction.

5. The DMF rate in children appears to be correlated with the total daily intake of assimilable fluorine rather than with the concentration of fluoride in the water (*2*). The average total daily intake should not exceed approximately 1.0–1.2 mg per day, including the 0.2–0.3 mg per day acquired from food. In northern communities, where the direct water consumption by children is nominal for most of the year and the total requirement of water is met largely by preformed water in the food or by liquid food such as milk, the 1.0 mg per day limit will be exceeded in relatively few instances when water contains 1.0 ppm fluoride; but in hot or arid climates, where children need and drink more water, the 1.0 mg per day intake may be exceeded frequently unless the fluoride content of the water is below 0.5–0.7 ppm (*1*).

6. To be effective in reducing dental caries, the fluorine ingested in food or water must be assimilable; that is, it must be able to pass from the digestive tract into the bloodstream and be carried to the teeth when the dentine and enamel are being formed. Although it appears probable that caries resistance is associated with the incorporation of fluoride or fluorine compounds into the tooth structure, the exact mechanism by which this process occurs still remains to be demonstrated (*1*).

7. The topical application of a 2 per cent solution of sodium fluoride to the teeth of children 7–17 years old appears to reduce the incidence of dental caries by as much as 40 per cent (*8, 9*).

8. The assimilation of fluorine from simple inorganic compounds—such as sodium fluoride, sodium silicofluoride,

and hydrofluoric acid, all of which have been used in the fluoridation of municipal water supplies—and the effectiveness of the substance in minimizing dental decay are influenced to the greatest extent by the solubility of the compound (*10, 11*), indicating that the dissociated fluoride ion is responsible for the cariostatic effect. At 18°C, the solubilities of some common inorganic fluoride compounds are (*12*):

Compound	Solubility at 18°C *ppm*
NaF	42,200
HF	∞
KF	923,000
CaF_2	16
MgF_2	76
Na_2SiF_6	6,520

At concentrations of 1.0 ppm fluoride or less, the solubilities of these compounds do not affect the availability of the fluoride ion for assimilation.

9. From complex fluorides and from organic combinations of fluorine, however, the availability and assimilation of fluorine are not too well understood. The absorption of concentrated doses of fluorine (3–6 mg per day) from bonemeal, cryolite, and calcium fluoride in food has been shown (*10*) to be considerably less than from sodium fluoride in food or water. Fluorine in tea, fish, and other foods, however, is definitely assimilable, and it has been shown to inhibit dental caries and even produce mottled enamel (*10*). The availability of fluorine in complex compounds appears to depend on the extent to which these compounds are hydrolyzed and metabolized by the body. Thus, sodium monofluoroacetate may be metabolized to furnish fluoride ion, whereas sodium perfluoroacetate does not appear to yield inorganic fluoride (*10*).

10. The presence and concentration of other elements in water may affect the action of fluoride ions. Selenium may reduce or negate the beneficial effect of fluoride ions (*13*), and high concentrations of magnesium may extend the threshold concentration of fluoride beyond which mottling of enamel occurs.

The essential features of the foregoing fundamental facts about fluorine can be summarized in a few brief statements: [1] fluorine is a trace element but not an essential element in human nutrition; [2] its ingestion in limited amounts in food or water has a cariostatic effect upon children's teeth; and [3] fluorine is available for assimilation and beneficial action from many simple inorganic fluorides that are soluble in water, and also from complex fluorine compounds that are hydrolyzed or metabolized to fluorides by the body.

With these fundamental data in hand, let us consider how fluorine can be administered best to children. The method and the concept that have grown in our midst is the application of fluorides to public water supplies. That this idea should have developed so easily is not hard to understand, for it was the natural fluoride content of certain waters that first drew attention to the cariostatic effects of fluorine. That the idea has developed so quickly to the exclusion or suppression of other methods for the internal administering of fluorine to children is attributable to the efforts of public health officials in promoting and publicizing water fluoridation and to the reluctance of some of these officials to

give proper consideration to alternate vehicles.

Water as a Fluoride Vehicle

The fact that the cariostatic effects of fluorine were first discovered in relation to the fluoride in drinking water is no reason why this vehicle should be considered necessarily as the optimum means of administering 1.0 mg per day to children. Certainly the British navy no longer relies exclusively on limes to prevent scurvy, nor are rice polishings now used as the principal nutrient supplement to combat beriberi. Other vehicles for vitamins C and B–1 have long since supplanted the original antidotes.

There are many convincing arguments for retaining the public water supplies as the optimum vehicle for fluoridation, and, in the opinion of many authorities, these arguments outweigh those in favor of alternate vehicles. Water is the most economical vehicle in most instances, despite the fact that less than 0.1 per cent of the added fluorides will be consumed by children (*14*). This economy occurs because water is handled by a public utility without packaging, marketing, labeling, or advertising. The techniques for testing the fluoride content of water are more rapid and accurate than the procedures for most alternate vehicles. Equipment and experience related to the addition of chemicals to public water supplies are readily available. Finally, water is consumed in some manner or other by *all* children within the area served by the distribution system, thereby assuring the benefits to all children regardless of their economic status or religious background.

There are other sides to the question, however, and, like the arguments in favor of fluoridation of public drinking water, those in opposition have a certain logic. Christian Scientists have protested against "mass medication," claiming that fluoridation of public water supplies forces an individual to take a medical substance or treatment against his will and against his religious beliefs. Although many public health–minded citizens may disagree in principle with this minority religious group, few Americans wish to violate the concepts of religious freedom or to incur the wrath of fellow citizens.

Just as fluoridated water reaches all children, so must everyone else drink or otherwise use it. Such water may possibly be detrimental to older people or to the chronically ill. Until such possibilities have been evaluated, the Delaney Committee (*9*) of the U.S. House of Representatives has urged caution in the fluoridation of public drinking water and has suggested further consideration of alternate vehicles that reach children effectively but are not compulsory. A precedent for this recommendation is offered by Rochester, N.Y., which abandoned iodization of its water supply owing to the adverse effect upon certain individuals sensitive to iodine and to the availability of an alternate and optional vehicle (iodized salt) for direct medication (*15*).

Approximately half of the people of the United States, who are living in small villages, suburban fringes, or rural areas, will not benefit by the fluoridation of public water supplies. Alternate vehicles for providing 1.0 mg per day of fluorides to the children

of this population should be developed (*1*).

The consumption of water by children is highly irregular, varying with season, temperature, humidity, and muscular activity (*2*). This extreme variation in water consumption may account, in part, for mild dental fluorosis in some children of a community served by water containing only 1.0 ppm of fluoride while other children in the same community have numerous caries. Maier (*16*) reports that Charlotte, N.C., offsets the seasonal variation in water consumption by adjusting the fluoride content of the water each month, from 1.1 ppm in January to only 0.6 ppm in July.

Most important of all of the arguments against water fluoridation is the fact that it starts a precedent for medication or nutrient supplementation through public water supplies. When this precedent has been established, only one step more is needed to add Vitamin B–12 to improve the growth of children, to add essential trace elements such as copper, or even to add other nutrients. Hitherto chemical treatment of water has aimed at the elimination of deleterious substances, such as bacteria, turbidity, color, taste, hardness, and iron; or at modifying the corrosive qualities of the water so as to protect pipes, tanks, meters, and other water works equipment. These objectives cannot be achieved by alternative methods. As Wolman (*17*) so ably stated:

> When we add a chemical to a water for the frank purpose of introducing a medical substance to treat the consumer rather than to modify the water, however, we enter a different area of practice.
>
> . . . practices for treating the diseases of the people in ways other than through the community water supply should be thoroughly evaluated from the professional and the economic standpoints. In general, such alternate practices, inherently more specific in their nature, are to be preferred.

Alternate Vehicles

Granted, then, that the objections to fluoridation of public water supplies have some merit and logic, is there any way that the advantages of fluoridation can be achieved without the disadvantages? To answer this question, it is necessary to investigate other methods, such as topical application, and other vehicles for ingesting fluorine, such as pills, dentifrices, bottled water or beverages, chewing gum, salt, solid foods, and milk.

The benefits of topical application are well established and many dentists practice the technique. Relatively few parents, however, are farsighted enough to request this service, and many are reluctant to pay the fees involved, especially for baby teeth. Tooth powders containing calcium fluoride or sodium fluoride are available, but they are not widely used and their efficacy in preventing dental caries has not been widely acclaimed.

Fluoridated pills, which are also on the market, show promise of fulfilling the need for a vehicle that can reach all those who desire the benefits of fluorides, even in rural areas. The danger exists, however, that some people might disregard the directions on the bottle and assume that, if one pill is good, two or more are better—thereby exposing their children to dental fluorosis from excessive fluoride. Chewing gum is neither an aesthetic way nor a reliable means to promote prophylaxis. Fluoridated salt would pro-

vide fluorides for adults—to whom it would be of doubtful value and possible harm—but a high proportion of children do not like salt on their food. Furthermore, careful control over the daily dosage would be difficult.

Bottled water fortified with sodium fluoride is available in Southern California, and its adoption overcomes the objections to the fluoridation of public supplies. Even when the local water contains 1.0 ppm or less of natural fluorides, there is little chance that a child will receive too much fluoride, inasmuch as he will tend to consume the bottled water in lieu of, rather than in addition to, the tap water. The sole disadvantage of fluoridated bottled water lies in its inherent high cost and the resulting fact that it reaches only a small proportion of the population. Parenthetically, it should be noted that fluoridated bottled water can remain complementary to, and will not necessarily be competitive with, the optimum vehicle as described below.

Food has been considered as a vehicle for fluoridation, and attempts have been made to increase the natural fluoride content of vegetables, fruits, and grains by adding calcium fluoride to the soil or water in which the plants are grown. The results demonstrate, however, that the fluoride content of the soil or water has little or no influence on the fluoride content of leaves, fruit, or roots. Only by the direct addition of fluoride salts to processed food could this vehicle be employed. Some consideration has been given to the enrichment of bread with fluorides, and, in Europe, where bread constitutes a large part of every child's diet, this proposal warrants further investigation. In the United States, however, bread consumption is irregular, especially among children. The search narrows, then, to liquid foods that are acceptable to, preferred by, and consumed largely by children; or, in other words, to milk.

Milk

The fluoride content of cow's milk, with no unusual fluoride in the cow's ration or drinking water, varies from 0.07 to 0.55 ppm, with a median value of 0.10–0.20 ppm (*3*). Furthermore, the addition of fluoride to the cow's ration or drinking water has no appreciable influence on the fluoride content of the cow's milk, the added fluoride probably being excreted in feces, urine, and perspiration, as it is for humans (*10*).

Inasmuch as the natural fluoride content of milk is too low to provide an adequate dietary supplement in the volume normally consumed by children, serious consideration should be given to artificial fluoridation of bottled milk. Such consideration involves questions of assimilation of milkborne fluoride, quantities and variations of daily consumption, effects of fluoridation on the palatability and nutritive value of milk, universal application, cost, reception by the public and the dairy industry, and modification of the pure food and drug laws.

From the previously enumerated fundamental facts, it appears that natural fluorides in food and milk, or artificial fluorides added thereto, are largely available for assimilation and, consequently, are as cariostatic as the fluorides added to drinking water. Preliminary tests (*10, 18*) indicate that milkborne fluorides are as caries inhibitory as waterborne fluorides.

There is no evidence to indicate that 1.0 ppm of the fluoride ion added to milk will not remain as undissociated and uncombined in the milk as it is in drinking water. Furthermore, any detrimental effects upon the palatability or nutritive value of milk remain to be demonstrated (*14*).

Milk consumption by children is subject to far less variation by age, sex, season, or climate than is water consumption. It is estimated that the average child consumes approximately 1.5 pints of milk per day. Most children from 2 to 8 years of age drink a glass of milk at each meal and possibly a midafternoon or midmorning glass. Moreover, milk consumption by children does not change much with season, temperature, or humidity, for children tend to vary their water consumption instead. Because milk is so filling, there are few children who drink more than 2 qt per day; if they do, such children could get 1 qt of fluoridated milk and one or more of the unfluoridated type. The more uniform consumption of fluoridated milk than of water should tend to reduce the variations in total fluoride intake from child to child and from season to season, and thereby should minimize the probability of dental fluorosis in one child while another in the same community has a deficient fluoride intake.

Some children, to be sure, do not drink milk, but they are relatively few in number. Deliveries of bottled milk in most metropolitan areas cover wider territories than do the municipal water supplies; in fact, almost all rural and suburban areas throughout the nation are well served with bottled milk.

The cost of chemicals for the fluoridation of milk is minor, especially as compared with the cost of fluoridating the entire water supply. There are other expenses, however, that make fluoridation more costly in milk than in water. Fluoridated milk must be handled, tested, bottled, labeled, distributed, and advertised separately from regular milk, and these added duties would require and justify a premium charge of approximately 1 cent per quart. This charge would be borne by the parents of the children who benefit, and not by the community as a whole. If all of the milk in a community were fluoridated, the annual per capita increase in cost would be $1.80 (based on an average daily consumption of 1 pint per capita and a surcharge of 1 cent per quart), as compared with 15–30 cents per capita for water fluoridation. For families with children, the discrepancies in cost would be even higher: $7.30 per family of two children per year for fluoridated milk.

The acceptance of fluoridated milk by the general public and its widespread use in urban and rural areas may reasonably be expected. It is sometimes surprising how rapidly the public will accept a new idea and clamor for its adoption in local communities, especially following a few newspaper editorials or advertisements or an article in a national magazine. That the public should oppose the concept of fluoridated milk, especially when its purchase is optional, seems inconceivable. Dairies could advertise the availability of fluoridated milk for families with small children, pointing out that regular milk is still sold for adults or for those who object to fluoridation. This optional feature should appeal to any religious group which now opposes water fluoridation.

Acceptance of the concept of milk fluoridation by the dairy industry and by the regulatory authorities is a much more complex problem. The pure food and drug laws of most states prohibit the adulteration of milk or the use of additives. Until such laws are modified or amended to permit fluoridation, enterprising dairies cannot proceed with the idea and the public cannot receive fluoridated milk. It is interesting to note, parenthetically, that an exception to the law has been made for Vitamin D, a concentrate of which is now added to milk.

The Food Protection Committee of the Food and Nutrition Board, National Research Council, has prepared a statement, entitled "Use of Chemical Additives in Foods," in which many aspects of the problem are discussed (*19*). First and foremost, an additive must not constitute a hazard to the consumer of the food, a hazard being defined as "the probability that injury will result from the use of the substance in the quantity and manner proposed." The mere presence of a substance is not in itself a hazard, unless the concentration exceeds a threshold value. Also, the wholesomeness and nutritional value of the food should not be impaired. Additives should never be used to cover up carelessness in sanitation or processing techniques. They should be considered only when a desirable property in the product cannot be obtained by other practical means.

The milk industry tends to look upon its products strictly as foods and may not like to see them used as vehicles for additives. The water works official looks upon his product as many things—as a weapon against fires, as a flushing device, as a washing agent, as a means of irrigation, and as a healthful beverage—and he, too, may not like to see it used as a vehicle for nutritional supplements. Apparently there are no laws, similar to the pure food and drug laws, that prohibit the adulteration of water by chemical additives. Hence, the regulatory agencies are in the paradoxical position of permitting the compulsory consumption of fluorides in water but prohibiting their voluntary consumption in milk. Between water and milk, which is the more logical vehicle to meet the need for fluoride supplementation of children's diets?

Summary

To summarize the case for milk as the optimum vehicle for fluoridation, the following advantages are reiterated:

1. Fluorides added to milk would be as assimilable and as caries inhibitory as those added to water.
2. Fluoridated milk would reach remote suburbs, small towns, and rural areas beyond the municipal water distribution systems.
3. Milk consumption is more uniform by season, age, and sex than is water consumption.
4. The use of fluoridated milk would be optional and could be avoided by religious objectors, the chronically ill, or the aged.
5. The cost of fluoridated milk would be borne by the families of the children who benefit rather than by the entire community.
6. If either milk or water *must* be used as a vehicle for a nutrient supplement, then milk is the more logical choice.

The disadvantages of milk with respect to water as a fluoride carrier are:

1. The overall cost of fluoridated milk for a community is higher than that of fluoridated water, owing to separate handling, labeling, and marketing costs. The discrepancy is even greater for families with children.

2. The procedures for determining fluoride in milk are not as simple as the technique for water.

3. Many pure food and drug laws prohibit the adulteration of milk by chemical additives. No such law restricts public drinking water.

Conclusion

This presentation of the possible case for milk rather than water as the optimum vehicle for fluoridation is intended not as a firm endorsement thereof, but rather as a stimulant to further thinking and research into the matter. The fact that many public health authorities have promoted water as the sole vehicle, the fact that the American Medical Assn., American Dental Assn., American Public Health Assn., and other associations have endorsed the program, and the fact that the AWWA has acquiesced, are not sufficient reasons for us to close our minds to new ideas or to discontinue the search for truth and logic. The members of the water works profession have a right to demand that alternate vehicles for fluoridation be considered and that public water supplies not be used for nutrient supplementation if logical and better alternatives are available.

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Discussion

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By titling his paper "A Rational Approach to Fluoridation," the author implies that our approach up to this time has been somewhat irrational. The assertion that the water fluoridation program has grown "like Topsy" is difficult to defend in the light of the record.

The fluoride–dental caries hypothesis which serves as the basis for the fluoridation of water supplies was developed over the years 1936–43 and culminated in a paper by Dean (*1*) which was supported by 86 references. In addition, the American Assn. for the Advancement of Science held two symposiums on the subject of fluorine and dental health, papers from which were published in 1942 and 1946 (*2, 3*).

The basic question of whether artificially added fluorides will serve the same ends as naturally occurring fluorides in preventing dental decay has been studied through well-planned experimentation on human populations at Newburgh, N.Y., Grand Rapids, Mich., and several other cities. The Grand Rapids studies have been under way for more than 8 years, and the Newburgh studies will provide 8 years of history in May 1953. Reports from these two cities and from several others are substantiating the original thesis upon which the experiments were based.

The practice of fluoridating water supplies has been scrutinized critically by special committees of the American Dental Assn., the American Medical Assn., and the National Research Council. Their verdict has been expressed by resolutions of support. Many other groups on the federal, state, county, and city level have done likewise.

It would seem, therefore, that our modern "Topsy" was conceived through selective breeding, was born under expert medical and dental supervision, and has been reared for the first 8 years of her life under the tutelage of professional men.

The author has taken pen in hand at this time because of his personal feeling that some other medium of supplying fluoride requirements would be more desirable than water. His conclusions are that milk should be given serious consideration. Many other men have pondered this same problem and have concluded in favor of water.

Factors Against Milk

The arguments for using milk as a vehicle appear quite plausible until one comes face to face with some of the real issues involved. In the appraisal of the optimum vehicle or method, one must keep in mind that a basic premise of good public health practice is to reach all people regardless of economic status. The principal factors against the use of milk appear to be as follows:

1. Numerous milk supplies would greatly increase the problem of supervision of any fluoridation plan.

2. Fluoridation would increase the cost of milk to the consumer, and, therefore, the benefits would not necessarily reach the low-income groups unless subsidized in some manner.

3. The legal aspects, as defined by present food and drug laws, present serious difficulties.

The addition of substances, such as fluorides to either water or milk requires the highest degree of supervision and protection. Such control, for milk, would be rather expensive because of the long and tedious assay methods involved. Small dairies would find it difficult to compete with large dairies which maintain a trained laboratory staff, and, therefore, the former could easily be forced out of business.

There is a growing trend away from the use of fluid milk as we know it, simply because the dairy interests are pricing themselves out of the market. Nutritionists and home economics experts are constantly teaching the people how to reduce food budget costs by using evaporated milk and reconstituted milk prepared from dry milk solids. It is well known that in many families the penny comes first and the children next.

The most formidable argument against serious consideration of milk as a medium for fluoridation centers around the food and drug laws, which in most instances are very strict concerning the addition of chemicals. Such exceptions as have been made were based upon the knowledge that a desirable effect would be obtained and that no other reasonable means of accomplishing the same results existed. In view of the fact that so many reputable professional organizations have gone on record as favoring water fluoridation practice, it would seem rather a hopeless task to obtain special consideration in the case of milk.

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Court Decisions on Municipal Water Fluoridation

By Walter W. Land and Edward K. Mosenthal

A contribution to the Journal by Walter W. Land and Edward K. Mosenthal, Attys., Berle, Berle, Agee, and Land, New York.

FLUORIDES were first artificially added to public water supplies in 1945. Since that time there has been considerable debate and public discussion on the merits of fluoridation. Although it is generally admitted that the fluoridation of drinking water achieves its stated purpose of a partial reduction of dental decay in children, there remains some conflict concerning alleged deleterious effects arising from such treatment of water used for drinking and industrial purposes. Most of the larger and more influential health and medical associations have endorsed fluoridation, and it has been the subject of investigation by numerous organizations, both public and private, including a committee of Congress.

Since 1945 the question has come up for consideration in many municipalities and has been adopted in many places. That fluoridation is a subject of active public discussion is shown by the results of public referendums in Seattle, Wash., and San Francisco, Calif., where the question was submitted to the voters for approval. Lively campaigns for and against the program ensued in both cities. In Seattle, fluoridation was rejected by a substantial majority, while, in San Francisco, it was adopted by a somewhat smaller majority. In spite of the variety of opinions on the subject, there were no legal tests of the validity of fluoridation until 1952. During that year five court decisions were handed down. The cases arose in Northampton, Mass.; San Diego, Calif.; Chehalis, Wash.; Baltimore, Md.; and Fargo, N.D.

These decisions, all of which upheld the particular fluoridation program adopted by local officials, may serve as precedents in future cases. The cases arose in courts well dispersed throughout the country, and they were much publicized. All the decisions were rendered in trial courts. Some are being appealed. In view of the unanimity of decision, however, it is likely that the courts' opinions will exert some influence and that a review of each case may be helpful.

Although common questions arose in the cases, each one will be discussed separately in order to present an adequate background for the litigation. With the exception of the Northampton case, the main issue presented was probably the contention that the fluoridation of municipal water supplies violated the Fourteenth Amendment to the Constitution, which indirectly protects persons from an invasion of their religious freedom by action of state and local governments.

Northampton Case

The city council of Northampton, on May 7, 1951, approved an order mak-

ing $7,500 available to the board of water commissioners for the installation of a fluoridation system for the municipal water supply. The water commissioners, after securing the approval of the Massachusetts Dept. of Public Health, installed the equipment, which was placed in operation on Feb. 19, 1952. Shortly thereafter a suit in equity (*1*) was brought in the superior court by ten taxpayers to enjoin the illegal expenditure of municipal funds for purchasing chemicals for fluoridation. A temporary restraining order was immediately issued. A hearing held a week later continued the restraining order until the case came up for hearing on the merits in June 1952. The plaintiff taxpayers based their argument on the contentions that the city council order did not give the water commissioners authority to purchase chemicals for the purpose of fluoridation and, in addition, that the order specifically mentioned only sodium fluoride, while the water commissioners were also using sodium silicofluoride.

After a hearing on the merits, Judge Broadhurst ordered that a decree be entered dismissing the plaintiffs' bill of complaint. In its opinion the court gave a brief history of fluoridation in Massachusetts, noting that it was first used in 1945 at the Belchertown State School, which is conducted by the Massachusetts Dept. of Mental Health, and has since been used in several other communities and institutions. Some were using sodium fluoride and some sodium silicofluoride, both of which had the approval of the state health department in accordance with the statutes of Massachusetts. The Public Health Council, on Dec. 5, 1950, issued a statement that the state health department would approve fluoridation applications from local water commissioners with the endorsement of the city council or board of selectmen.

The court held that the respondents, the Northampton water commissioners, had complied with this procedure.

It was within the discretionary power of the respondents to use fluoride in the treatment of the city's water supply without authority from the City Council, provided they had, as they did have, the approval of the State Dept. of Public Health and of the City Council for an appropriation for the purpose. The appropriation order of May 7, 1951, gave the assent of the City Council to the plant and appropriated the sum named. I find that the use of the words "sodium fluoride" in the order was intended to include also the compound sodium silicofluoride.

The treatment of a municipal water supply with either one of the compounds has not been practiced long enough in Massachusetts or elsewhere in the country to prove that it will have the expected effect of preventing or retarding dental caries in the children or in anybody else. There is no evidence that its use in a water supply will be detrimental to the health of consumers.

I find on all the evidence that the expenditure of the unexpended balance of the appropriation made by the City Council on May 7, 1951, for fluoridation of the water supply of the city of Northampton with either sodium fluoride or sodium silicofluoride will not be an illegal expenditure or an expenditure for an illegal purpose. A decree is therefore to be entered dismissing the bill of complaint.

It is noteworthy that the court, although upholding the legality of the fluoridation program, did not put any stamp of approval on it. It held only that the advisability of the plan was within the discretion of the water commissioners. No constitutional issue was raised, the only question being whether the expenditure of funds was illegal under local law.

San Diego Case

In October 1951 the San Diego city council held a public hearing to determine whether or not a water fluoridation program should be adopted. A full opportunity was given to all interested persons to attend the hearing. Evidence was presented and arguments were heard. On Oct. 25, 1951, the city council adopted a resolution instructing the city manager to proceed with fluoridation of the city water supply. Five days later it adopted a further resolution authorizing and directing the city manager to apply to the state board of health for permission to add 1 ppm fluoride in an approved compound to the water supply and, upon obtaining such approval, to take the steps necessary to put such a program into effect. The latter resolution contained a recital that the council was of the opinion "that it will be in the interests of the public health and dental health of the residents of San Diego and the water consumers of said city to treat the water" with an approved fluoride compound.

Before the system was put into operation, C. Leon de Aryan brought an action in the Superior Court of San Diego County against the mayor and city of San Diego seeking to restrain the defendants from carrying out the directions of the city council resolutions. A temporary restraining order was issued.

The case (*2*) was heard before Judge Sherry. After a hearing on the merits, a judgment granting a motion for nonsuit (dismissal on the merits) was handed down in April 1952. The contentions of the plaintiff were that the program, if carried out, would invade the constitutional rights of many of the citizens of the city and was contrary to law because: [1] it would subject them to mass medication; [2] it invaded their rights of religious freedom; [3] it was unduly harsh and oppressive in the absence of an emergency; and [4] there was no epidemic and the program would not prevent contagion or infection. The city asserted that the program constituted a valid exercise of the police power granted by the state constitution.

At the trial, the plaintiff introduced oral testimony and numerous documents consisting of reports on fluoridation projects in other areas. The court commented on this evidence by stating that "this proof indicated the subject is highly controversial." The court went on to say that it was not concerned with the wisdom of the program, which was solely for the determination of the city council. This was a legislative function beyond the province of the judiciary branch to set aside.

The court discussed at some length the general principles and history of the expansion of the police power and summarized this issue as follows:

> The police power should be given the broadest application; and this power is increasingly exercised in keeping with advances made in the science of medicine and sanitation in recent years. Accordingly, courts are reluctant to place limits on what may be done in the interest of the health of the community so long as unreasonable methods are not employed nor the natural or constitutional rights of the citizens invaded.
>
> The judicial branch of government has no authority to interfere with the legislative or governmental acts within the scope of the city's authority nor to disturb the city's findings that the program is necessary or proper to protect the public health; nor to determine the wisdom of the policy.
>
> Thus, in determining whether or not the particular measure is reasonable, the

test involves the determination as to whether: [1] it is for the benefit of the community in general, that is, for the general welfare; and [2] the means adopted to produce the public benefit are not unduly oppressive upon the individual.

The first question is whether or not the "mass medication," if the adoption of the program here under attack may be so called, is in itself violative of any of the fundamental rights of the people of the city. No authorities have been cited on behalf of the plaintiff in support of that proposition, nor are any known to the court. On the other hand, the finding by the city council that the program is in the best interests of the people is controlling on the court. [Citations omitted throughout.]

On the issue of whether there was any violation of the religious freedom of those whose beliefs are opposed to taking medicine, the court stated:

Religious freedom embraces two concepts: freedom of *belief* and freedom to *act*. The first is absolute, but in the nature of things the second cannot be, in that all acts or conduct of our citizens must conform to all reasonable regulations adopted by the respective governmental agencies acting within the scope of their authority. (*Rescue Army* v. *Municipal Court,* 28 Cal. (2d) 460, 470.)

In this connection our [California] State Supreme Court has said:

"There can be no question, therefore, that a person is free to hold whatever belief his conscience dictates, but when he translates his belief into action he may be required to conform to reasonable regulations which are applicable to all persons and are designed to accomplish a permissible objective." (*Rescue Army* v. *Municipal Court, supra* (citing U.S. Supreme Court cases). To the same effect, *Hamilton* v. *Regents,* 293 U.S. 245 (Calif.); *Gabrielli* v. *Knickerbocker,* 12 Cal. (2d) 85.)

Therefore, no constitutional rights of any of the citizens of San Diego to freedom of religious belief would be invaded or violated by the adoption of the proposed program.

Plaintiff's arguments that it was necessary for the defendant city to show that an emergency, epidemic, or danger of contagion or infection existed were rejected. The court found, based on precedents, that the city need only show that a particular measure "was reasonably necessary to promote the public health."

The word "necessary" was not strictly or narrowly defined. The decisions defining the extent of local police power require only "that there must be a finding by the City Council in this case that the measure was desirable, proper, beneficial, convenient, or suitable to the promotion of public health of the people of the city. The City Council, at least inferentially, found that the program would be desirable and beneficial generally to the people of the city, when it recited in Resolution No. 104213 that the program here involved 'would be directly in the interests of the health of the people of the city. . . .'"

Plaintiff's contention that the program, if carried out, would constitute a trespass on his person was disposed of on the ground that he could show no injury by the adoption of the program. At most, he could show only that it was highly controversial and that it was debatable whether the consumption of fluoridated water would injure anyone. The court cited a recent case (*3*) in which the U.S. Supreme Court went so far as to say that it was not beyond the scope of constitutional authority for a legislative body to experiment with new techniques.

It was held that the proposed program was not in conflict with California law, including the California State Health and Safety Code regulating the

advertisement, sale, and use of certain drugs. Plaintiff's contention that the rejection by the state legislature of a bill authorizing public utilities to fluoridate public water supplies constituted a declaration of public policy against fluoridation was found to be without merit.

Although, as stated above, the court refused to make any findings on the effects of fluoridation, it concluded that the legal authorities "demonstrate convincingly that the adoption of the fluoridation program here involved is a valid exercise of the police power of the city."

Chehalis Case

In an action (*4*) against Chehalis, Wash., the plaintiff, a taxpayer, sought to enjoin the city from proceeding with its program to fluoridate the municipal water supply under an ordinance passed by the city commissioners. The ordinance recited that the director of public health and the state health department, as well as various health and medical associations, had recommended fluoridation. The costs chargeable to the fluoridation program for equipment and installation amounted to $2,862.12, not including the cost of sodium silicofluoride, at 10 cents per pound, which was to be used at the rate of 35–40 lb per day.

Each side introduced testimony concerning the nature and effect of fluoridating the water supply. The plaintiff introduced evidence showing that only approximately one-fifth of the population consisted of children between 6 and 14 years of age and contended that the introduction of fluorine constituted mass medication, the effects of which were uncertain and possibly dangerous. The defendants relied on the experience of other communities using water containing fluorides and claimed a reduction of 50–60 per cent in tooth decay in communities using fluoridated water. The defendants also claimed that water containing 1 ppm fluoride did not cause mottled teeth nor did it constitute mass medication, but was solely a preventive measure which was in no way harmful to either adults or children. The defendants further showed that the fluoridation program would be carried out under the rules and regulations of the state health department, that the equipment and procedure would be inspected, and that water samples would be submitted. The equipment to be used was standard recognized equipment, and all reasonable safeguards were to be taken. It was admitted on cross-examination that moving equipment is subject to wear and possible breakdown and that there was a remote chance of error.

The legal arguments of the plaintiff were that fluoridation constituted compulsory medication in violation of the due process clause of the Fourteenth Amendment and the state constitution, that it involved the unlicensed practice of medicine and dentistry and the unlawful dispensation of drugs, and that the ordinance did not meet statutory requirements. The defendants maintained that fluoridation was a public health measure valid under the city's police power and did not constitute compulsory medication but a proper expenditure under a valid ordinance.

In an opinion rendered on Nov. 5, 1952, the court, at the outset, recognized that the subject of fluoridation was "an extremely controversial one." As in the cases previously discussed, it refused to go into the merits of the program from a scientific or medical viewpoint:

> The questions to be determined by this Court are purely legal and constitutional

questions, and will be dealt with only from that standpoint. It is of no consequence or importance whether I personally approve or disapprove of fluoridation.

The court found that the state constitution and state law expressly granted the city power to prevent the introduction and spread of disease, to make and enforce regulations for the protection of health and good order, and to provide for the general welfare. These powers are usually included within the scope of local police powers granted to municipalities. Under state court decisions, it was established that the local police power is broad enough to include not only public health measures, but also all regulations the purpose of which is to promote public convenience and the general welfare. The court found that the city commission, in considering the program, had reliable information before it and was justified in concluding that fluoridation would constitute a public health measure. It noted that this was a legislative decision, the wisdom and necessity of which were not subject to judicial review, and that the legislative judgment was entitled to a strong presumption of constitutional validity. Judges are traditionally reluctant to interfere with legislative enactments.

It is a health measure and, consequently, within the police power of the city to act upon. Surely in the progress of government and better living conditions, from a physical and scientific standpoint, a plan or program for the betterment of teeth, or to prevent the very common disease of tooth decay, is one that government should undertake, unless it violates the rights of citizens to be free from some interference or compulsion. Even though it is within the police power and a plan or program is provided by ordinance, it seems to me the court cannot interfere unless the program is in violation of the plaintiff's constitutional rights, and only then where there is absent the 'imminent peril' to the public welfare.

In discussing the duty of the city in supplying water to the community, the court said:

It is the duty of the city to furnish a wholesome water supply free from contamination and one that will not be injurious to health.

The evidence in this case convinces me that the addition of fluoride ion in the proportion of 1 ppm will not amount to contamination and the water will continue to be wholesome.

On the other hand, the citizen has no right, either under the constitution or otherwise, to have water supplied him by the city that is entirely free from such chemicals as may be proper in preventing disease and protecting the user's health. If this were true, a citizen could object to the chlorination as well as fluoridation of the water. It is true that chlorine is added to affect either bacteria or plant life in the water, while fluorine has no effect upon the water, but remains as a fluoride ion in the solution. Yet the overall effect is the same, namely, to prevent disease.

The plaintiff asserts that this amounts to mass medication, that he is compelled to use the water, therefore, his constitutional rights are invaded.

In support of his contention that his constitutional rights were invaded, the plaintiff relied upon several cases which the court summarized as standing for the rule that the police power may override the rights of individuals only when required by public necessity or in the case of clear and present danger. It recognized that these cases involved clearly defined constitutional rights and implied that no constitutional rights of the plaintiff were invaded:

In the present case it doesn't appear to me that there is any constitutional right invaded. The city is furnishing, and under the program will furnish, wholesome water, and whatever is done will be done under the direction and supervision of the Health Department.

The court also held that, although fluorine might come within the statutory definition of a drug, its addition to the water supply did not constitute unlicensed sale of drugs. A distinction was made between selling drugs and furnishing water for the purpose of aiding public health. The court found that the definition of practicing medicine contemplated the use of drugs in the treatment of disease. It noted that defendants' witnesses contended that the application of fluorine was a preventive measure and not medication. Although no specific finding was made on this point, it was concluded that the program did not constitute the practice of medicine, dentistry, or pharmacy.

The other contention of the plaintiff, that the program required the city to exercise its police power beyond its territorial limits because the water supply was situated outside the city boundary, was also rejected.

Baltimore Case

At Baltimore (*5*), two individual plaintiffs sought to obtain temporary and permanent injunctions to restrain the city from introducing fluorine into the water supply. Only one of the plaintiffs appeared in court and testified.

On Nov. 13, 1950, the city council, after reciting that the American Dental Assn. approved the fluoridation of water, resolved that the water bureau and the health department should study the desirability of such a plan and should proceed with executing it if the study indicated such action was desirable. A further resolution, adopted on Feb. 25, 1952, provided that the health department should request the commissioner of health and the water engineer to give it available information on the fluoridation of city water supplies. The resolution stated that there was disagreement among scientists as to possible harmful effects of fluoridation on certain persons.

On Mar. 10, 1952, an additional resolution calling for a delay in fluoridation was introduced. This resolution was based on the claim that there was considerable uncertainty about the wisdom of adding fluorides to the water supply and that it would be a "wise step" to postpone further action until additional information was obtained. A public hearing was held on this resolution, and it was defeated in the city council by a vote of seventeen to four.

The commissioner of health reported favorably to the city council in accordance with its original resolution, and he and the water engineer proceeded with the program of fluoridation.

The court, in an opinion by Judge Manley, held that the designated municipal officials were not only permitted, but obligated, to comply with the provisions of the council resolutions, which it found were properly adopted. Aside from urging that the city had not acted properly under local law, the principal contentions of the plaintiffs were that fluorine was a toxic substance which would have a deleterious effect on aged persons and on persons suffering from certain diseases, and that it constituted a calculated risk which had not yet been sufficiently investigated. One of the plaintiffs also made the objection that the ingestion of fluorine required him

to submit to medication, which was contrary to his religious beliefs.

The court reviewed the evidence presented by the defendants concerning the effects of consuming fluorine. In addition to the finding of the commissioner of health, the testimony of several scientists and reports from various organizations were presented. It was noted that the Baltimore City Dental Society, the Maryland Medical Society, and the Maryland Board of Health all recommended or approved fluoridation. On this point, the court concluded:

> We must rely on scientists and doctors and dentists in technical affairs of this kind, and when we have an honest opinion given after a careful study I think it is entitled to great weight and should be adopted, so I find from the evidence that there is nothing in this proposed program that would be deleterious to the health of the people of Baltimore City, and I do not find from the evidence that the addition of fluorine to the water supply is a calculated risk of any kind.

In disposing of the constitutional argument that the plaintiff's freedom of religion was invaded, the court pointed out that it was debatable whether the addition of fluorine constituted medication, which is contrary to the Christian Science faith, of which the plaintiff was an adherent. The court did not decide this question but cited and quoted from the San Diego case previously discussed (*2*) and other cases, including a famous 1890 decision of the U.S. Supreme Court (*6*) concerning the right to espouse polygamy as a religious belief:

> The term "religion" has reference to one's views of his relations to his Creator, and to the obligations they impose of reverence for his being and character, and of obedience to his will. It is often confounded with the *cultus* or form of worship of a particular sect, but is distinguishable from the latter. The first amendment to the Constitution, in declaring that Congress shall make no law respecting the establishment of religion, or forbidding the free exercise thereof, was intended to allow everyone under the jurisdiction of the United States to entertain such notions respecting his relations to his Maker and the duties they impose as may be approved by his judgment and conscience, and to exhibit his sentiments in such form of worship as he may think proper, not injurious to the equal rights of others, and to prohibit legislation for the support of any religious tenets, or the modes of worship of any sect. . . . There have been sects which denied as a part of their religious tenets that there should be any marriage tie, and advocated promiscuous intercourse of the sexes as prompted by the passions of its members. And history discloses the fact that the necessity of human sacrifices, on special occasions, has been a tenet of many sects. Should a sect of either of these kinds ever find its way into this country, swift punishment would follow the carrying into effect of its doctrines, and no heed would be given to the pretense that, as religious beliefs, their supporters could be protected in their exercise by the Constitution of the United States.

The Baltimore court's opinion drew the common distinction between the right to believe and the right to act in connection with religious freedom:

> There is no question that under the Constitution of both the United States and the State of Maryland a person has a right to believe in any particular religion or faith that he cares to, but he does not have the absolute freedom to act in accordance with the tenets of any of those religions, but in his action he is bound to follow the laws duly enacted for the preservation of the health of citizens generally. He cannot object on religious grounds to laws enacted either by national, state, or city authorities. I find

in this case that from the evidence none of the constitutional rights of the plaintiff to freedom of religious belief would be invaded or violated by the adoption of the proposed program.

Fargo Case

In April 1952 the Fargo, N.D., city commission unanimously adopted a resolution to introduce fluorides into its water supply for the purpose of reducing dental decay in children. The introduction of sodium silicofluoride into the water was begun on May 28, 1952. One week later an action was brought by an organization called the Fargo Civic Betterment League seeking a permanent injunction against the city officials in an attempt to prevent the continuance of the fluoridation program. No attempt was made to secure a temporary injunction to restrain the continued introduction of fluorides during the progress of the action.

The defendant city filed a demurrer to the suit, which was sustained after argument on Aug. 19, 1952. According to newspaper accounts (7) of the judge's decision, he expressed certain doubts in his memorandum opinion concerning the issues involved. He noted that the operation of the city's water plant constituted the exercise of a proprietary and not a governmental function, presumably questioning whether the plaintiffs had any standing to complain about such activity. The plaintiffs failed to allege clearly that they were taxpayers or to show that their rights as taxpayers were financially involved when the municipal water supply was not supported by taxation. Judge Burtness was bothered by the fact that the city had "pretty much of a monopoly on the business of selling water," although drinking water was available by purchase from other sources. Although expressing doubt, he said that he did not think fluoridation came within the prohibitions under the state food and drug act and the state pharmacy law.

No extended discussion of the constitutional issue was recorded. The court's decision was partly based on the procedural ground that sustaining the demurrer would simplify the proceedings for appeal to the state supreme court. "An order sustaining a demurrer is appealable; an order overriding a demurrer is not. It would seem that a trial would entail the use of lengthy controversial testimony of experience on both sides which would not be particularly helpful to the Supreme Court in passing upon the ultimate constitutional questions involved."

The plaintiffs' amended complaint was also dismissed on demurrer on Dec. 31, 1952. Judge Burtness again found that the plaintiffs' rights as taxpayers were not being violated because the cost of fluoridation was being borne by the purchasers of the water. He pointed out that there was a close issue concerning the contractual rights of water customers. Concerning the effect of fluoridation, the judge pointed out that the advisability of the program should be left to the sound discretion of the city commission, the governing body of Fargo. The complaint contained no specific allegation that the health of the individual plaintiffs or any other water consumer had been impaired in any manner. The newspaper report again contained no discussion of the constitutional issue other than a reference to the San Diego case.

Conclusions

Aside from the varying requirements of local law, which differ in each state and community, the main common issue arising out of cases concerning

the power of local governments to add fluorides to the water supply has centered around the contention that such a program involves an invasion of religious freedom. This question arose in all the cases discussed except in Northampton. In each case, the religious argument was rejected, although the grounds for doing so were not always entirely clear. It seems established that fluoridation is a valid exercise of the police power unless it conflicts with some constitutional protection accorded to the individual. In the San Diego, Chehalis, and Fargo cases, it was at least implied that the plaintiffs had no standing to raise the constitutional question because they could show no injury or invasion of their rights.

Assuming that the consumption of fluoridated water is contrary to the religious beliefs of certain persons, and avoiding the debatable question whether consumers of municipal water are entitled to have the water remain free from particular substances which do not render it impure or unwholesome, there is very little legal authority on the particular issue. Most of the older cases on freedom of religion involved criminal sanctions for doing or failing to do certain acts. As a legal matter, persons are not required to drink water from the city water supply, although, as a practical necessity, they may be forced to. The element of compulsion by the state or local government is lacking. The decisions reviewed show that the courts are reluctant to base their opinions on this ground, or on the ground that the plaintiffs lack standing to raise the constitutional issue.

There also exist legal articles (*8, 9*) expressing the viewpoint that there are no sound constitutional or legal objections to a properly planned and executed fluoridation program. An exception to this view is contained in an article published in 1952 which advances the argument that fluoridation is not only unconstitutional but is contrary to the state law of California (*10*). Some of the arguments contained in this article were advanced in the San Diego case and were not considered controlling by the court.

Based on the foregoing court decisions and the other available legal authorities, the only possible conclusion is that, upon compliance with local law, there is no legal obstacle to adopting and carrying out a fluoridation program. For this reason, it would appear that the decision of a legislative body on the matter is controlling and that the desirability of initiating or continuing fluoridation of a public water supply can properly and usefully be argued only before the local governing body.

References

1. *Herbert v. Gare* (No. 8853).
2. *de Aryan* v. *Butler* (No. 169974).
3. *Day-Brite Lighting, Inc.* v. *Missouri*, 342 U.S. 421.
4. *Kaul* v. *City of Chehalis* (No. 21896, Superior Court of Lewis County).
5. *McFarlane* v. *Mayor and City Council of Baltimore* (Baltimore Circuit Court).
6. *Davis* v. *Beason*, 133 U.S. 333.
7. Fargo, N.D., *Forum* (Dec. 1952–Jan. 1953).
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Expansion of the Colorado River Aqueduct System

By Robert B. Diemer

A paper presented on Oct. 31, 1952, at the California Section Meeting, Pasadena, Calif., by Robert B. Diemer, Gen. Mgr. and Chief Engr., Metropolitan Water Dist. of Southern California, Los Angeles.

THE chief purposes for which the Colorado River Aqueduct was planned and constructed were: [1] continuation of the long trend of population and industrial growth in Southern California without limitation or restraint due to lack of available water supply; [2] replenishment of the region's underground water storage basins (seriously depleted as a result of a half century of remarkable overdevelopment) by spreading or by partial and temporary decreases of well pumping; and [3] protection against at least the major effects of droughts.

The 1950 census indicates the substantial accomplishment of the first objective. Without the aqueduct the unprecedented growth of Southern California would not have occurred. How long this growth can be sustained by the aqueduct is a matter of opinion. The question is largely academic for present purposes.

The best example of what can and, indeed, must be done regionally on a large scale to achieve the second objective is shown by the excellent replenishment results obtained in the relatively small Pasadena Basin. By limiting the pumpage, under a court adjudication decree, to the estimated safe yield of the basin and supplying all additional requirements from the Colorado River Aqueduct, water levels of wells have been effectively restored in spite of years of subnormal rainfall and runoff. Basin ground water storage has thus been stabilized and an invaluable asset preserved for the future. Elsewhere, only a beginning has as yet been made, particularly in Orange County and the West Coastal Basin—and this only within the last 3 years. An election in December 1952 may initiate ground water replenishment in the large Central Coastal Basin of Los Angeles County. Apart from the Pasadena Basin, however, and a favored few other subbasins not as yet overpumped, it remains to be determined whether efforts toward the second objective must finally be described as "too little and too late." There is probably still time, using off-season surplus aqueduct capacity, to replenish the depleted ground water basins of the coastal plain for the protection and preservation of future generations.

The third objective—a remedy for droughts—is being achieved by the Colorado River Aqueduct. The severe 7-year drought of 1944–51 proved this fact beyond debate.

Early History

The aqueduct is truly a product of the threat of drought. The project was first proposed in 1923 by the late

William Mulholland, Gen. Mgr. and Chief Engr., Los Angeles Dept. of Water and Power. Reconnaissance surveys were made in 1924 and a $2,000,000 bond issue was approved by 1931 an aqueduct construction bond issue of $220,000,000 was approved by the voters of the thirteen cities then composing the Metropolitan Water Dist. All four of these decisive years

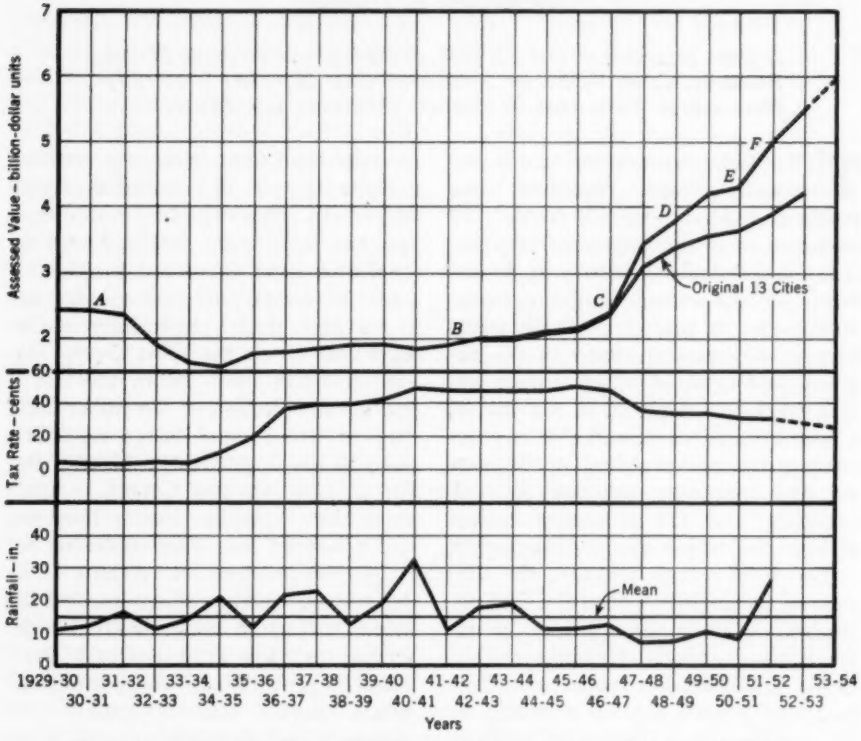

Fig. 1. Los Angeles Rainfall and District Tax Rate and Assessed Value

The italic letters indicate annexations to the Metropolitan Water Dist., as follows: A—*Compton, Fullerton, Long Beach, Torrance;* B—*Coastal Municipal Water Dist.;* C—*San Diego County Water Authority;* D—*West Basin Municipal Water Dist.;* E—*Pomona Valley Municipal Water Dist.;* F—*Eastern, Orange County, and Chino Basin municipal water districts. The relationship of drought to Metropolitan Water Dist. growth is evident.*

the Los Angeles voters in 1925. All three years were excessively dry in Southern California, with a composite index of only 60 per cent of normal rainfall. Intensive surveys and studies followed in 1928–31. In September were severely dry, with a composite index of 75 per cent of normal rainfall. Financial difficulties due to obstructionist litigation and the depressed bond market in 1932 were overcome with the aid of the U.S. Reconstruction

Finance Corporation toward the end of that year. Fortunately, the lack of progress was somewhat offset by above-normal rainfall in 1932. With the late Frank E. Weymouth as general manager and chief engineer, aqueduct construction work was carried on at full speed after 1932, particularly during the 1933–36 drought period. Three of these four years were severely dry in Southern California, with a composite rainfall index for the period of 89 per cent, ending in 1936 with only 77 per cent of normal rainfall for the region. Water levels in numerous ground storage basins fell to unprecedented low elevations, and there were numerous requests from water users in such basins that the aqueduct's completion be expedited at any cost.

As the aqueduct is chiefly a supplemental water supply project, the situation changed radically during the wet period, 1937–44, when 6 of the 8 years (instead of the usual ratio of 3 in 8) had above-normal rainfall, with a composite regional index for the period of 131 per cent of normal. This was the wettest series of years in the history of Southern California. The immediate need for an imported water supply, almost regardless of cost, promptly disappeared. Time became available for more economical, normal-speed completion of the aqueduct and its distribution system, and also for the construction of the first unit of the Weymouth Softening and Filtration Plant at La Verne, Calif. Meanwhile, during 1939 and 1940, aqueduct pumping plants and transmission lines were thoroughly tested, resulting in the initial filling of aqueduct reservoirs.

Water deliveries from the aqueduct began in June 1941 on a very limited scale, with Santa Monica the chief customer until 1945. During the first three years of operation, or until the end of the record-breaking wet period, annual deliveries averaged 5 bil gal—only 8 per cent of the 1951–52 total of 64 bil gal. Total deliveries, including both softened and natural Colorado River water, have shown an increase in every year since 1941, with the first interruption of this trend coming in the current season of 1952–53. Aqueduct operations during 1941–51 were under the supervision of General Manager and Chief Engineer Julian Hinds. Since January 1952 the author has held the position of general manager and chief engineer.

Effect of Drought

A most significant change in the controlling rainfall conditions, and, therefore, in the general aqueduct situation, began in 1945 with the end of the 8 wet years and the start of a very severe, continuous 7-year drought. Much longer and more severe droughts have certainly occurred in the 180-year recorded history of Southern California, but these have generally been interrupted by an occasional season of above-normal rainfall, considerably reducing many of the worst effects.

For the period 1945–51 the regional rainfall index was 70 per cent of normal, but the last 4 years were much more severe, with an average index of only 57 per cent (below 50 per cent in 1948). The municipal and industrial water supply problem during the long drought was substantially a shortage of aqueduct connections rather than a shortage of water. This fact is emphasized by the recent expansion and annexation program of the Metropolitan Water Dist.

Figure 1 shows the rainfall records for Los Angeles from 1929 to 1952, in-

clusive. Also shown are the assessed valuation of the district, the tax rate per $100 assessed valuation, and the various annexations to the district during these years. It will be noted that the first real activity toward annexation occurred in December 1946, the third drought year, when the San Diego County Water Authority was annexed.

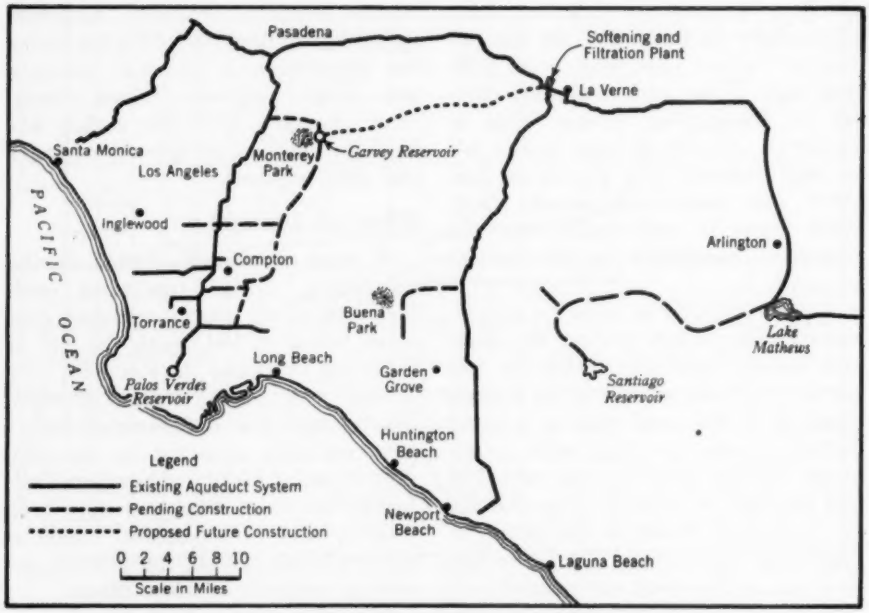

Fig. 2. Colorado River Aqueduct Distribution System

The total length of the existing distribution mains, exclusive of the San Diego Aqueduct (not shown), is 178 miles. The main aqueduct, from the Colorado River intake near Parker Dam to the western terminus at Lake Mathews, is 242 miles long.

areas have been annexed since that time. The service area has been increased from 600 to 1,570 sq miles as of October 1952, owing chiefly to the persuasive educational effects of the recent drought. The assessed valuation has increased from 2 to 5.5 billion dollars. The district now includes 47 incorporated cities, plus numerous suburban communities, with a population exceeding 4,000,000. Elections to be held in 1953 may increase the district's area to approximately 1,900 sq miles and its assessed valuation to above 6 billion dollars. A growth that might well have required a full generation or more has been compressed by the drought into a short

At the time the bond election was held in 1931, the district consisted of thirteen cities with an area of 600 sq miles. In the 15-year construction and operation period prior to the start of the long drought, there occurred only one annexation, the Coastal Municipal Water Dist. of Laguna Beach and vicinity, in 1942. Six additional

and hectic 5 years, with "growing pains" and headaches galore.

As the maximum potential area of the district probably does not exceed 2,500 sq miles, the present service area corresponds to 62 per cent of the potential, compared with 22 per cent in 1942. This near approach to maturity, occurring much sooner than might have been anticipated, involves heavy obligations for future wholesale water service to the newly merged areas. The district's total allotment from the Colorado River is 1,212,000 acre-ft. This amount will meet the supplemental demands of the area, which has a supply of 1,200,000 acre-ft from local sources.

There are attendant advantages in this swift growth. The district tax rate fell from 50 cents per $100 assessed valuation in 1946 to 28 cents in 1952, with continued rate cuts in prospect. A further important advantage is the opportunity, now being used, to plan and design needed additions to the aqueduct distribution system with locations and capacities most economical and logical for future operations. The original member cities were generally noncontiguous and widely scattered, compared with the large, but compact and all-inclusive, municipal water districts that have grown out of the regional drought problems and are being accepted for membership. The increased water demands corresponding to this great growth in service area make necessary the major additions to and expansion of the aqueduct system that are now under way.

Aqueduct System

The aqueduct, with a designed capacity of 1,605 cfs, diverts water from the Colorado River at the intake pumping plant, 2 miles above Parker Dam and 150 miles below Hoover Dam. The aqueduct is 242 miles long, terminating at Lake Mathews Reservoir. There are five pump lifts with a total head of 1,617 ft. At each plant, only three of the ultimate nine pump units of 200-cfs rated capacity were installed initially. The aqueduct also includes 92.1 miles of 16-ft diameter tunnel, 54.4 miles of covered conduit, 62.8 miles of concrete-lined canal, 1.1 miles of unlined canal, and 28.7 miles of inverted siphons. The total cost of the main aqueduct, including Parker Dam, to June 30, 1952, was $139,880,000.

The distribution system extending from Lake Mathews has a capacity of 750 cfs to the Weymouth Softening and Filtration Plant near La Verne; west of this point to Pasadena, the capacity is 510 cfs. Figure 2 shows the distribution system serving the district member areas and proposed additions to serve increasing demands. Branch lines terminate at Santa Monica, Palos Verdes Reservoir near Torrance, and the Orange County feeder near Newport Beach. The San Diego Aqueduct, which extends 71.1 miles from the San Jacinto tunnel (approximately 25 miles east of Lake Mathews) to the San Vicente Reservoir, is not shown. Exclusive of the San Diego Aqueduct, the total length of the distribution mains, varying in diameter from 2 ft to 12 ft 8 in., is 178 miles, including 16.5 miles of tunnels. The storage for the system is supplied by Lake Mathews, 104,000 acre-ft; Morris Reservoir, 35,000 acre-ft; and three small operating reservoirs, 1,215 acre-ft. The 100-mgd softening and filtration plant was enlarged in 1949 to 200 mgd. The ultimate capacity will be 400 mgd. As of June 1952, the total cost of the distribution system, including dams and softening plant, was $66,683,000; of

this amount $7,062,000 represents the district's share of the San Diego Aqueduct. The total cost of the aqueduct system was $206,563,000.

Expansion Program

To meet the rapidly increasing demands on the aqueduct system, the district has a $52,000,000 program under way, the major portion of which is planned for completion by July 1955. The principal features of this construction program include the installation of two additional pump units, with motors and discharge pipes, at each of the five pumping plants; 125 miles of 30–72-in. distribution lines; and a 1,500-acre-ft operating reservoir. The second barrel of the San Diego Aqueduct is estimated to cost $18,000,000, half of which is at the expense of the Metropolitan Water Dist.

Under a recent contract, an immediate start has been made on the previously deferred half-capacity distribution line from the Lake Mathews outlet works. Eventually this line will be completed across Orange County to the Los Angeles–Long Beach harbor and industrial region. At present it is planned to build only the initial feature of this line, a 10-ft ID, 7,500-ft concrete-lined tunnel of 750-cfs capacity. From the west portal of the new tunnel there is planned, for the immediate benefit of the recently annexed Orange County Municipal Water Dist., a pipeline of 250-cfs capacity. This will later be paralleled by a second line when added capacity is needed.

This line will extend 25 miles to Orange County, with deliveries into the Santiago Reservoir (Irvine Lake) and into the two large canals on the south and north banks of the Santa Ana River. A spillway will be constructed so that aqueduct water can be discharged directly into the Santa Ana River, below the canals, for spreading and percolation purposes to aid in the replenishment of the underground water basin. This aim is now being accomplished, less satisfactorily and on a smaller scale, by discharging aqueduct water through the blowoff valve in the upper feeder line north of Lake Mathews at the bridge crossing the Santa Ana River, near Arlington.

The projected pipeline from Lake Mathews will carry natural Colorado River water, purified by long storage in aqueduct and Colorado River reservoirs. This untreated water is preferable for irrigation and percolation purposes because it is economical (the wholesale rate to members is now $10.00 per acre-foot for raw water, half the charge for softened, filtered water) and because both the low sodium content and the hardness-forming constituents like calcium bicarbonate are relatively beneficial for the maintenance of good texture and quality of soil.

In contrast, other sections of the Orange County Municipal Water Dist., which are also short of water, need and prefer a softened, filtered source of supply for municipal and domestic purposes. For such rapidly growing communities as Buena Park, Garden Grove, and Huntington Beach and vicinity, a new pipeline is to be constructed, to distribute softened aqueduct water from the La Verne–Laguna Beach line. This line will connect with present and proposed pipelines of local water districts and mutual water companies. When it becomes necessary, this supply will be supplemented by a connection to the new Lake Mathews line and the eventual construction of a second softening plant to serve communities in Orange

County and the southern sections of Los Angeles County.

Another very important part of the present expansion program consists of the new Garvey Reservoir, for distribution and regulating purposes, to be located high in the hills of Monterey Park. Its capacity will be 1,500 acre-ft, with a nominal maximum water elevation of 570 ft above sea level. It will improve and supplement the water service to the present members of Compton, Torrance, Long Beach, and West Basin Municipal Water Dist., as well as the southeast industrial sections of Los Angeles. In addition, it will be of great value and importance to the cities and industrial sections southeast of Los Angeles, if these areas are annexed to the Metropolitan Water Dist.

New pipelines leading into and out of Garvey Reservoir will form a grid system, together with the lines of the present system, and will later connect with the deferred lower feeder pipeline that will lead from Lake Mathews.

Present plans provide for the construction of a 6-mile line, 60 in. in diameter, connecting Garvey Reservoir with the present Palos Verdes line on the east boundary of Los Angeles. Extending south of Garvey Reservoir will be a 72-in. line, with a capacity of 250 cfs, to connect with the existing Victoria Street line. When increasing water demands require additional capacity into Garvey Reservoir, this middle feeder line will be extended east to La Verne, a distance of 21 miles, where the capacity of the upper feeder is adequate to supply the needs. Other pipelines soon to be constructed from the middle feeder are an extension of a 3-mile line, 45-in. in diameter, to connect with the Long Beach lateral, and a 6-mile line, 60-in. in diameter, to serve a middle Los Angeles delivery. A new line, approximately 4 miles long, will also be constructed to serve the annexed area in Inglewood and vicinity. This line will originate at the existing Palos Verdes feeder.

All planning and design for this expansion program of the aqueduct distribution system have been carried on in close cooperation with the water departments of the interested member cities, with advance agreement on needed water pressures and elevations, economical routes and points for connections to local systems, and anticipated water demands.

Conclusion

The chief conclusion so far developed from the program outlined is that present construction costs are about three times greater than the aqueduct's original 1933–39 costs for identical features. This fact naturally makes the responsible officials wish that somewhat less strenuous efforts had been made 15 years ago to defer every possible item of construction, in order to reduce the bond interest burden during the intervening years. Because the present inflation ratio could not reasonably have been anticipated so long ago, however, this feeling of regret merely emphasizes the bargain that newly annexed districts are now receiving. They are being permitted to merge with and buy into the Metropolitan Water Dist. by means of a back-tax charge amortized at 3 per cent interest over the next 30 years on the basis of the original depression period construction costs (approximately $207,000,000) rather than the present reproduction costs (estimated at $650,000,000) of the aqueduct project. The back-tax charge includes the

annual tax payments that the area would have made if it had been one of the original members, plus interest at 4 per cent from the due date of each payment to the date of annexation.

It is further concluded that the benefits of the present expansion program, the major portion of which is planned for completion early in 1955, will be available none too soon, judging from continuing trends of population and industrial growth in Southern California. In fact, the program may not be finished quite soon enough, if delays due to such factors as nonavailability of essential materials are going to plague the construction industry to any substantial degree during the next 2 years.

Revision of American Standards for Pit Cast Pipe and Cement Mortar Lining

In addition to approving certain new standards for cast-iron pipe (March 1953 JOURNAL, p. 307) the American Standards Assn., on Jan. 13, 1953, gave final approval to certain revisions in A21.2–1939, "American Standard Specifications for Cast Iron Pit Cast Pipe for Water or Other Liquids," and A21.4–1939, "American Standard Specifications for Cement Mortar Lining for Cast Iron Pipe and Fittings."

Because the changes in these two standards are not extensive enough to warrant republication of the complete texts in the JOURNAL, the new versions will be available only in booklet form. The price of specification A21.2 (also known as AWWA C102) is 45¢; A21.4 (AWWA C104) is 35¢. Both may be obtained from AWWA headquarters, 521 Fifth Avenue, New York 17, N.Y.

A21.2

In A21.2, the principal revisions are the following:

Sec. 2–3—Quality of Iron. Permissible sulfur content increased.

Sec. 2–5—Foundry Records. Procedure expanded and codified.

Sec. 2–12—Cleaning and Inspecting. Hammer test eliminated.

Sec. 2–13—Hydrostatic Test. Hammer test eliminated.

Sec. 2–16—Test of Material. Full-length bursting tests permitted.

Sec. 2–19—Full-Length Bursting Tests. New section.

A21.4

In A21.4, the principal changes include:

Sec. 4–2—Sand. Additional sieve test specified.

Sec. 4–3—Accepted Specifications. Sand ignition test eliminated.

Sec. 4–5—Mortar. Option of omitting sand withdrawn.

Sec. 4–7—Method of Applying Cement Mortar Lining. Correction of defects described.

Sec. 4–10—Thickness of Lining. Section reworded.

Sec. 4–11—Determination of Thickness. Nonpenetrating gage method permitted.

Sec. 4–12—Curing. Bituminous seal coat specified, and new method of curing described.

Sec. 4–13—The Finished Lining. Loose spots not permitted.

Sec. 4–14—Bituminous Outside Coating. Type of coating must be agreed upon.

Sec. 4–15—Whitewash. Section eliminated, but Note 4 to Sec. 4–13 covers the subject.

Sec. 4–16—Frequency of Tests. New section.

Sizing and Maintenance of Meters at Akron

By L. W. Bausher

A paper presented on Sept. 18, 1952, at the Ohio Section Meeting, Cincinnati, Ohio, by L. W. Bausher, Asst. Engr., Akron Bureau of Water and Sewerage, Akron, Ohio.

AKRON, Ohio, has since 1948 pursued a program designed to increase the percentage of "billed water." The main elements of this program include resizing of old meters, proper sizing and maintenance of new meters and services, and repair and testing of all meters larger than 1½ in. (*1*).

Customers in Akron are divided into two classes, domestic and nondomestic. The former consists of single-family and small multiple-family dwellings, and commercial or industrial establishments served by meters 1 in. or smaller. Nondomestic customers are those using meters 1½ in. or larger. A third classification covers fire protection service.

The major points of Akron's policy of control of services and meters may be summarized as follows:

1. All services (main to property line) are installed by the city at the customer's expense.

2. The maximum size of service is one size smaller than that of the main. The smallest nondomestic service is 1¼ in., the next size being two 1¼-in. services tied together.

3. If a building has two or more services from different street mains, as is often done to assure continuous service, a check valve must be installed on each service to eliminate cross flows through the building.

4. All fire protection installations having a tight sprinkler system may use a detector check installation. This consists of a weighted check valve combined with a ⅝-in. disk meter on a bypass for the purpose of detecting leaks. The detector check does not record water passing through the main line but only that which flows through the bypass.

5. Fire service installations having hose cabinets or fire hydrants, either with or without sprinkler systems, require a meter of the compound type in which a proportional meter and an automatic valve on the main line are combined with a disk meter on a bypass for the purpose of measuring all rates of flow with a minimum loss of head. The minimum charge on a fire service so metered is less than on a service metered with a detector check, but the initial cost of the fire service meter is considerably more. The customer has the right to furnish and install a fire service meter on tight sprinkler systems, thus reducing the standby charge. Regardless of the type of meter, water used for fire-fighting purposes is not billed, in accordance with state law.

6. Installations combining fire protection and nondomestic use require a fire service meter with a current type bypass meter, the latter being a com-

pound rather than a disk meter. The fire meter with a compound bypass picks up smaller flows and is better suited for combined fire and nondomestic use. When using a fire meter with a current type bypass, an attempt is made to have the bypass meter record all of the normal use, the main-line meter opening only in the event of fire. The normal (industrial) use may, however, exceed the capacity of the bypass meter as delivered from the factory. In some meters, additional weight may be added to the automatic valve in the main line, thereby delaying the opening of the main meter and causing higher rates of flow to be recorded on the bypass meter.

In two installations, additional weight was added to 6-in. meters, raising the changeover point approximately 50 gpm with very little increase in the pressure loss. Before additional weight is added, Meter Master * charts are run to obtain peak rates of industrial use, thus establishing the maximum rate at which the bypass meter should record before the main-line meter opens. At both locations, the added weight is working very satisfactorily, causing the industrial use to be recorded on the bypass meter only.

All meters furnished by the customer or the city are delivered by the manufacturers to the water department meter shop for an acceptance test before installation. All 1½-in. and larger meter settings require a bypass and test tee.

Resizing of Meters

A study of nondomestic services is now in progress, and meters are being resized where necessary. At more than 150 installations, meters have been checked and reduced in size. Only in a very few locations have meter sizes been increased. When existing meters are found to be obsolete or beyond repair, a new meter is installed. The resizing program is coordinated with the sizing of all new meter settings.

A Meter Master is used to check a meter for correct size. Rates of flow are recorded by this instrument on a circular chart for periods of 6, 24, or 72 hours. The 6-hour chart is used when checking the maximum and minimum rates of flow. The 72-hour chart is employed for weekend and Sunday rates, which are usually lower than on weekdays. These charts permit accurate sizing of the meter. In previous years, Akron practice, in common with that of other cities, was to use meters of the same size as the service line, instead of suiting the meter to the demand required. Using a meter larger than necessary increases both the initial and the maintenance cost and results in inaccurate registration of small flows.

At this point, it may be appropriate to mention an additional application of the meter checking device. When complaints of large bills are received, the Meter Master chart is photographed and sent to the customer, showing him when and how much water passed through the meter. A record of large flows at night, when no water is being used, is clear evidence of leaks.

Sizing of New Services

Experience during the resizing program indicated that much of the work would have been unnecessary if there had been proper coordination between the water department and the customers. Therefore, a policy of coordina-

* A product of F. S. Brainard and Co., Hartford, Conn. A description of this device and its use has been given by Bell and Walasyk (*2*).

tion in the installation of new services and meters has been adopted. When sizing a new service and meter, the architect is consulted and the water uses are tabulated, listing all fixtures and allowing for air conditioning and refrigeration.

The water department recommends the size of service, based on water demand and pressure required. If the architect has noted a nonstandard size of service on his plans, the next larger size is used, which is always agreeable to him.

Another problem is the location of the meter. If the building is to be more than 60 ft from the property line, or if it has no basement, the meter is required to be at the property line. Otherwise the meter may be installed in a suitable place in the basement.

When a 1½-in. or larger meter is set at the property line, a meter pit must be constructed to the specifications of the water department. Blueprints are furnished covering all sizes and types of meters. The meter pit has to be large enough to accommodate a meter of the same size as the service from the main. The piping in the pit consists of a bypass around the entire setting and an inlet valve and meter, followed by a test tee and outlet valve. In a 4-in. service, for example, the inlet and outlet valves would be 4 in., with the proper spacing for a 4-in. meter. The correct size of meter is then installed, using reducing spools when the meter is smaller than the piping. If the meter site is in the basement, the same type of installation is used as in a pit.

Testing and Maintenance

With the proper size of meter in place, it is the responsibility of the water department to maintain the meter in the best possible working condition. As previously mentioned, a program of overhauling and testing all meters 1½ in. and larger, amounting to approximately 400, was started in 1948. This work is continuing and occupies a foreman and five men full time.

At the start of the program, the 1½- and 2-in. meters were brought to the shop to be overhauled and tested. A more efficient method has since been found: the chamber, disk, gear train, and change gears for a particular size and make of meter are repaired in the shop and tested in a spare case; the parts are then taken into the field and substituted for the worn parts of a customer's meter. This is done in one field trip, and the meter case need be opened only once. A bypass around the meter insures that the customer is never without water during the change.

After the initial overhauling and testing of the 1½- and 2-in. meters were completed, a program of field testing was begun. Field tests are now run on the meters every 12–18 months, depending on the amount of water recorded.

The equipment used for field testing consists of a shop-tested 2-in. disk meter bypassed by a ¾-in. meter for small flows. Both meters are connected to a 2-in. portable rate-of-flow indicator, to check rates from 0.25 to 175 gpm. The indicator is approximately 40 in. long, including a vertical, tapered, calibrated glass tube which records the flow, a 2-in. lubricated plug valve to control the flow, a 2-in. spring-loaded check valve at the outlet to keep the instrument full of water, and four adjustable supporting legs. When flows larger than 35 gpm are to be tested, a 2-in. gate valve is opened wide, so that 80 per cent of the flow bypasses the vertical tube and the rate

is read from an auxiliary scale mounted alongside it. The test equipment, which is easily set up and dismantled, is carried in water department trucks.

When field-tested meters are found to be inaccurate, adjustments are made with change gears. Accuracy corrections of more than 3 or 4 per cent should not be made with change gears but by replacing worn parts.

Three-inch and larger meters are overhauled in the field by taking the meter apart and, if necessary, bringing the parts to the shop for cleaning. The worn parts are replaced, the remaining parts are cleaned, and the meter is reassembled. A field test with the portable testing equipment is then run on the meter, carefully checking the changeover point on all compound meters. The overhauling and testing of 3-in. and larger industrial meters, in conjunction with the use of the Meter Master, have caused approximately 60 meters to be reduced in size.

When a customer-owned meter larger than 4 in. needs replacing, a letter is written to the customer explaining the work done on the meter, the test results, and the reason it must be replaced. In the letter, the city offers to buy the old meter at a predetermined price. Very little trouble has been encountered in making such changes. If the meter size can be reduced enough (4-in. size or smaller) so that the water department will furnish the meter, the customer is notified to that effect. In all such instances, the water department's recommendations have been accepted. The customer is thereby relieved of the purchase and maintenance cost of the new meter.

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Actinomycetes in the Oklahoma City Water Supply

By J. K. G. Silvey and A. W. Roach

A contribution to the Journal by J. K. G. Silvey, Chairman, Science Div., and A. W. Roach, Asst. Prof. of Biology; both of North Texas State Coll., Denton, Tex.

TASTES and odors are common in surface water supplies in the southwestern part of the United States. Dallas, Tex., from 1933 to the present has dealt with this problem and from time to time has experienced unusual outbreaks so intense that the filtration plant was unable to produce a palatable water. The same conditions have been noted in Breckenridge, Ranger, Waco, Corsicana, Austin, and the Rio Grande Valley of Texas, as well as in towns and cities in Oklahoma. Unusual odors also occur in the middlewestern, eastern, and western parts of the United States, but little reference will be made to the type or intensity of those odors, as the authors have not had an opportunity to examine the agents responsible for their production.

It has been the desire of sanitary engineers, water purification chemists, and other individuals interested in the production of domestic water to find a simple and economical procedure for controlling tastes and odors in water supplies. Chlorine, chlorine dioxide, ozone, carbon, and many other substances have been used in purification plants, with varied results. Descriptions of the tastes and odors range from fishy to earthy, musty, haylike, manure, geranium, or generally offensive. In many instances, the characteristic odor may be described by several terms, and not infrequently disagreements occur among the experts. One common point of agreement, however, is that the odors were due to either algae, microscopic animals, or general organic decomposition. If algae were present, either as attached forms or planktonic organisms, the odor was attributed to algae. If great numbers of microscopic animals were observed in the water supply, the odor was attributed to these forms. If neither of the above groups appeared in sufficient concentration to produce tastes and odors, the condition was ascribed to general organic decomposition, probably effected by bacteria and similar organisms. The only investigators who have made serious attempts at isolating the compounds responsible for tastes and odors are Ruchhoft, Middleton, and Braus (*1*) at the U.S. Public Health Service Environmental Health Center in Cincinnati, Ohio.

The early work of Silvey and others (*2*) indicated that tastes and odors in southwestern reservoirs could be attributed to actinomycetes. Laboratory culture of various organisms from different lakes throughout the Southwest gave rise to by-products that had tastes and odors similar to those found in the lakes. The purpose of this account is to make a definite contribution to the knowledge of tastes and odors in southwestern reservoirs. The organ-

isms responsible for the tastes and odors have been isolated, identified, and cultured. The habitat and ecology of these organisms have been worked out sufficiently so that definite statements may be made concerning both the cause of tastes and odors in the Oklahoma City, Okla., supply and the methods of controlling the actinomycetes. It is the belief of the authors that this contribution is rather specific for Oklahoma City, as the construction of its reservoirs is unlike that of typical reservoirs throughout the Southwest. Identification of other actinomycetes from additional water supplies, however, points to the fact that this group doubtless contributes a high percentage of the tastes and odors in surface supplies.

Taylor (*3*) recounted the taste and odor problem in Oklahoma City in considerable detail. In his paper he gave a description of Lake Overholser and Lake Hefner, which serve the city as reservoirs for its surface water supplies. Lake Overholser is located on the north fork of the river proper, adjacent to a diversion dam. The reservoir is shallow and subject to considerable turbidity during high winds. Average turbidities are approximately 100 ppm, but the range of variation is 10–3,000 ppm. The present capacity of Lake Overholser is approximately 17,000 acre-ft. From time to time since its construction, tastes and odors have appeared in the Oklahoma City water supply.

Lake Hefner, the second reservoir supplying the city, is located 4½ miles from the North Canadian River. The lake is filled by a diversion canal which crosses from the North Canadian River to the reservoir proper. The entrance to the canal from the river is controlled by gates which are opened during times of high water so that better grades of soft North Canadian water may be chosen for the Lake Hefner reservoir. Tarzwell (*4*) wrote a preliminary report on the taste and odor problem in the Oklahoma City supply. More details concerning the volume, plant operation, and chemical treatment may be secured from that paper or from Taylor (*3*).

Observations

The Lake Hefner water treatment plant was placed in operation on Dec. 16, 1946. In the beginning it was observed that the water had a fishy, swampy, woody odor. As the season progressed, the odors became more intense. Studies of the plankton in the lake indicated that the number of organisms was not great, and, so far as could be discerned, few types existed that had a history of producing offensive tastes and odors. Ivan Ophel of the University of Oklahoma made extensive studies of the plankton organisms in both Lake Overholser and Lake Hefner. The types of organisms and their concentrations gave few or no clues to the actual cause of the intense odors in the raw water.

In an attempt to make the water usable, Oklahoma City employed chlorine dioxide, prechlorination, and other special treatments for the removal of the tastes and odors. The greatest success was obtained by the use of carbon. Charles P. Hoover of Columbus, Ohio, and C. E. Taft of Ohio State University, after examining the samples of water, were inclined to think that the algae present were not responsible for the tastes and odors.

The authors' first contact with the Oklahoma City supply was in February 1951, when the threshold odor number was 22. The plankton counts were low. The water had a temperature of approximately 3°C and was ex-

tremely clear, with marginal ice formations in the region of the riprap on the north side of the lake. Samples of raw water from Lake Overholser, North Canadian River, the diversion canal, Lake Hefner, and the Lake Hefner purification plant all yielded growths of actinomycetes. These organisms were reared in liquid culture and the by-products they produced were extracted. It was noted that the by-products, when placed in odor-free water, had identically the same characteristics as the odors then found in the lakes.

In the latter part of the spring, observations on the Oklahoma City water supply revealed that the actinomycete count was lower and that the plankton count was higher, but that the threshold odors had decreased. The city was handling the odor problem very effectively with activated carbon. The cost of the effective removal of the tastes and odors at that time was approximately $20 per million gallons. Costs were higher during the winter. The routine threshold odor tests which were instituted have proved to be most useful, because the appearance of odor in the raw water and at the various stations throughout the purification process, including the tap water, can be followed in detail.

The types of odors produced by the Oklahoma City actinomycetes are very offensive when the threshold odor number reaches 5, while water at 14 is unbearable. Consequently, it was the desire of the city to produce water with a threshold odor as low as 1 or 2, if possible.

Experimental Work

Actinomycetes isolated from the water supply in July 1951 were studied in great detail. It was found that four genera of these organisms were present. Some of them grew in shallow water and some in deep water, while others developed in marginal vegetation. All of them required relatively high concentrations of nitrogen. Inorganic compounds, including phosphorus, did not appear to contribute to their physiology. On June 1, 1951, the authors began a research program in which they investigated the limnology, fish life, and general ecology of the lakes. This information is essential to the investigator for an understanding of the conditions under which various actinomycetes grow.

In the fall of 1951 it was noted that odors were beginning to increase in Hefner as well as in Overholser. Detailed examinations of all sections of the lakes ultimately disclosed the habitat of the actinomycetes that were contributing the tastes and odors to the lakes. In the construction of Lake Hefner reservoir, more than 18,000 ft of riprap was placed across the north end of the lake and extended to the northeast and the northwest. Lake Overholser was almost completely surrounded by similar construction and concrete. As the prevailing spring, summer, and fall winds are from the southwest, wave action on the riprap is vigorous during most of the warm season. Concurrent with the high wave action, one may observe growths of thick-matted green algae along the riprap, concrete, or soil. At Oklahoma City, this algal form, known as *Cladophora*, may extend up 2–3 ft above normal lake level and grow 2–4 ft beneath the surface of the water.

Cladophora has not generally been considered to be of sanitary significance except as a contributor of organic matter. Sets of weighed samples of the wet *Cladophora* indicated, however, that the riprap on the lakes supported about 3 tons of wet organic matter per

mile. As the planktonic forms in the lakes were low most of the time, the authors began a detailed study of the *Cladophora* growths. Laboratory investigations and cultures did not yield any specific information. Examination by phase microscopy divulged minute organisms living in the interior of the cells of the green algae. Past observation had shown the same type of organisms, and the authors had concluded that certain bacteria were attacking the *Cladophora* and slowly bringing about their decomposition. In order to be certain of this, however, masses of *Cladophora* filaments were placed in small glass homogenizers and crushed. Cultures made from the algal remains contained thousands of colonies of actinomycetes, some belonging to the genus *Micromonospora,* some to *Streptomyces,* others to *Nocardia,* and one to a genus that has not yet been described and appears to be new. The rearing of these various types of actinomycetes in pure cultures yielded by-products that were responsible for the tastes and odors.

Methods were perfected for the immediate eradication of the marginal algae. As the waters of the Oklahoma lakes are highly alkaline and relatively hard, copper sulfate is not as effective as copper citrate or copper acetate. Various members of the engineering group of the Oklahoma City water supply, under the direction of M. B. Cunningham, have constructed sprays that can be carried either by boat or on a truck boom so that the riprap may be treated continuously. Soon after the riprap became free of *Cladophora,* the threshold odors began to drop. Because the eradication of the algae gave rise to free available nitrogen and phosphorus, certain blue-green algae began to grow, which necessitated the application of copper to Lake Hefner. As long as *Cladophora* are kept off the riprap and the actinomycetes mentioned above do not find a similar nitrogen source, their numbers are so low that intense odors do not occur.

It should be mentioned that blue-green algae, such as *Anabaena, Oscillatoria,* and *Aphanizomenon,* furnish adequate nitrogen to support copious actinomycete growths and, consequently, are associated with tastes and odors in surface water. In like manner, certain diatoms, such as *Melosira,* provide nutrition for aquatic actinomycetes and are associated with tastes and odors. Actually the algae are not the odor and taste producers but may serve appropriately as "index organisms," because they contain the nutrient sources on which certain aquatic actinomycetes depend. Additional sources of nutrition for aquatic actinomycetes may be higher types of vegetation, microscopic animals, and remains of plant and animal matter high in available nitrogen.

It is now possible to explain why Oklahoma City experienced intense tastes and odors during the middle of the winter—formerly a very baffling problem. Because the actinomycetes were residing in the interior of the green algae, and because their activity was not sufficient to kill the algae in great masses, a slow exudation of their by-products was finding its way into the water supply. With the advent of cold weather and the changing of the wind from the south to the north, the *Cladophora* above the water line began to disintegrate and freeze, resulting in the fragmentation of the exposed *Cladophora* filaments and the seeping of the actinomycete by-products into the water supply. As these compounds are more soluble in cold than

in warm water, the problem of treating the water was both difficult and expensive. So long as a nutrient source for the aquatic actinomycetes is not available, tastes and odors from these organisms cannot occur. At present the threshold odor number of the raw water in Lake Hefner is approximately 1 or less, a very satisfactory situation for the filtration engineer.

It is worth while to describe the characteristics and general morphology of the actinomycetes. The following section of the paper is presented so that those interested in taste and odor problems may be able to use the material in identifying the real cause of the tastes and odors in their surface waters.

Identification

Recognition of actinomycetes is not difficult if the water plant has laboratory facilities for making standard plate counts of microorganisms. An effective means of eliminating most of the fungi and bacteria in isolation, so as to give the more slowly growing actinomycetes an opportunity to develop, is to prepare nutrient agar with twice to three times the normal complement of agar. About 10 ml of the concentrated agar is placed in a sterile petri dish, and, just before solidification, 5 ml of water sample is placed evenly over the top of the agar. The agar rapidly absorbs the excess water, and the bacteria, mold spores, and actinomycetes are deposited on top. In incubation, the bacteria, yeast, and fungi succumb to dehydration, and within 14 days the actinomycetes appear on the surface of the dry agar.

An actinomycete colony on an agar plate can be distinguished from colonies of bacteria or other fungi by the fact that it is round and lusterless and generally contains a pattern of concentric rings. The colonies of the other fungi are usually irregular, while bacterial colonies are moist and shiny and do not have ring patterns. Few actinomycetes exhibit the slimy colony characteristic of bacteria, and usually their colony is either dome or saucer shaped or, less commonly, flat. The color varies from white to gray or tan to cream, or the colony may be straw colored or banded in rings. Other typical characters of the group as a whole are the brown-to-black discoloration of the agar and the types of odor mentioned earlier that are produced by most strains. In pure cultures inoculated with a large quantity of spores, the surface growth on most agars becomes coalescent, massive, and ridged, and the circular and ringed appearance of the individual colony is lost.

Microscopic identification is absolute and may be quickly accomplished by using the following technique: remove the colony and some of its agar with a loop, spread it on a slide in a drop of water, flame the slide, add one drop of gentian violet stain, permit the slide to stand for 2 min, and wash with water. A microscope equipped with an oil immersion lens should be used, as the actinomycetes are very small and difficult to see.

An actinomycete slide will show a branching system of filaments and thus cannot be confused with bacteria (Fig. 1a). Other fungi can be distinguished easily because actinomycete filaments, and their spores, are much smaller, measuring 0.3–1μ in diameter. One precaution to be observed is to make such slides only from colonies that are 3 days old. If slides are made from

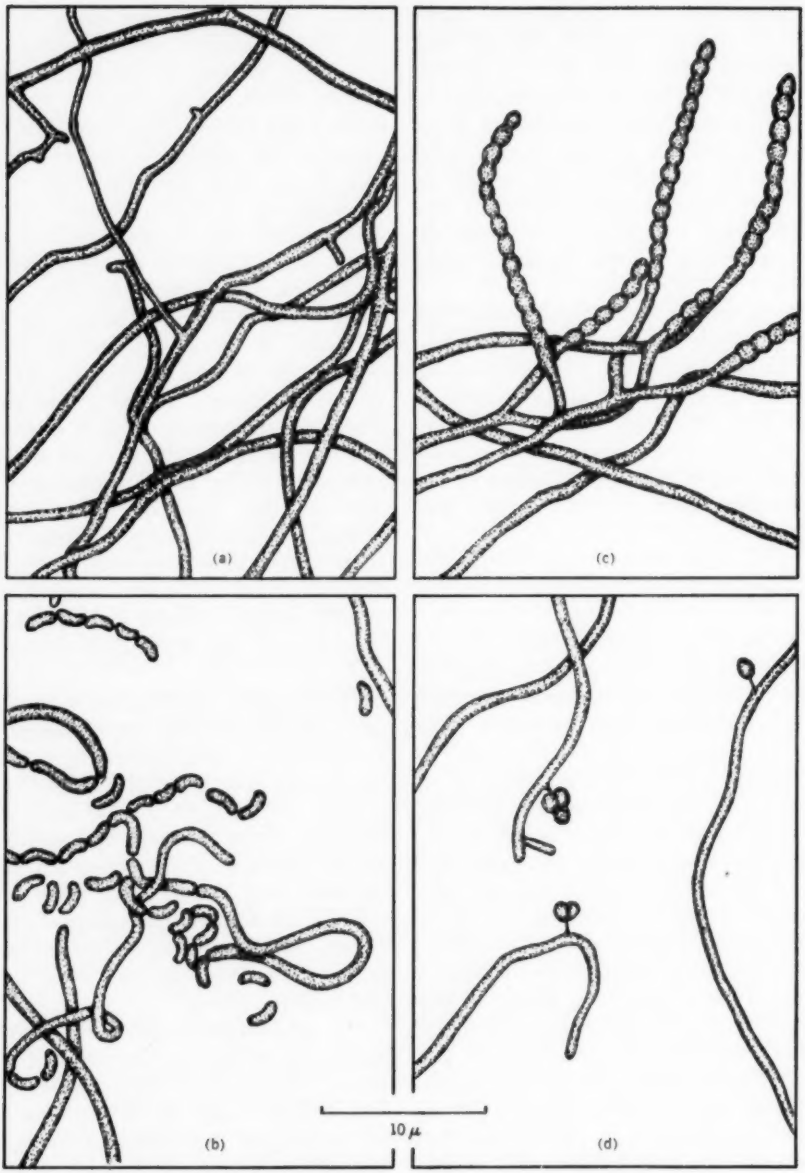

Fig. 1. Characteristics of Aquatic Actinomycetes

Key: (*a*) *typical branching mycelium;* (*b*) *filament fragmentation of* Nocardia; (*c*) *spore chains of* Streptomyces; (*d*) *lateral spores of* Micromonospora.

colonies older than 3 days, the spores of the actinomycetes resemble certain bacteria.

The genera or main groups of actinomycetes are four in number and are distinguished primarily on the basis of sporulation, spore arrangement, and breakup of the filaments, as well as by cultural characteristics which will not be considered. For all practical purposes, the primary characters are sufficient for recognition. The first genus, *Actinomyces,* is entirely parasitic and, therefore, will not be found in water. The second genus, *Nocardia,* is related to the first vegetatively because its threads, too, are not stable and may take an acid-fast stain. *Nocardia* never forms spores, and, in most species, the filaments break up into bacillus-like segments (Fig. 1b) after 3 days. The third genus, *Streptomyces,* has a stable mass of filaments (they will show up in a slide made at 7 days) which produce spores in chains that resemble a string of beads (Fig. 1c). The fourth genus, *Micromonospora,* also has a stable vegetative body, and its spores are single or grouped in grapelike clusters on small side branches from the filaments (Fig. 1d).

Actinomycete taxonomy is a relatively new field. In this group, as in many of the transition forms between the bacteria and the lower fungi, past investigations have confused the real situation because of inadequate knowledge of the variability of the forms. Waksman (*5*), a soil microbiologist, reduced 23 genera to the four named above when it became evident that actinomycetes would be of great economic importance owing to their antibiotic production. Most of the work has been done on soil forms, and an extensive monograph on this group as a whole failed to recognize several basic structural and habitat data revealed in the authors' investigation of the Oklahoma strains.

The authors' initial taxonomic investigation of aquatic actinomycetes was based on thirteen strains taken from the Oklahoma lakes in July 1951. These were transferred from stock cultures to a number of different media, and their development was followed closely over a 7-day period. Observations on the odor production, size, color, shape, and surface of the colonies were noted and Gram-stained slides taken every 24 hours. Microscopic data from photomicrographs of these slides were interpreted and recorded. The strains will be discussed under their separate genera as groups rather than as separate species. This is in accord with present practices because of the extreme variability within a single form. After an entire year's sampling of these lakes has been studied, the species groups can be definitely designated and effectively published according to the rules of nomenclature.

Six strains may be placed in two groups under the genus *Streptomyces.* First, it is noteworthy that this genus has never been reported from American water before, although it is the most common genus and odor producer that the authors have encountered in samples from southwestern water supplies. The 73 species recorded in *Bergey's Manual* (*6*), the ecological classification of Waksman (*5*), and all other writers place these forms in soil, air, and refuse habitats. The first group of strains had well-developed, dome-shaped colonies which were white and cottony, becoming gray with white spots at maturity in the cultures where growth completely covered the agar.

The individual colony progressively grayed from the edge to the center. The spore chains were straight and usually long, and the vegetative filaments formed internal segments 0.1μ in diameter at 24 hours. This characteristic was reported for a few soil strains of *Streptomyces* earlier in this century, but Erikson (*7*), a leading English investigator, believed these reports to be erroneous. The authors feel, however, that it is constant and valid in aquatic forms. Agar discoloration was brown to black, and odor production appeared at 72 hours.

The second group of *Streptomyces* strains had smaller, dome-shaped colonies which were straw-to-cream colored and usually aggregate. Spore chains were relatively short, and no internal segmentation was found in the filaments. Agar discoloration and odor appeared at 48 hours, became intense at 72 hours, and was almost unbearable at 7 days.

Four of the strains belong, in the authors' opinion, to an *intergrade* and will be designated as such until effectively published and given a valid generic name. These forms grew as white colonies which produced an orange slime ring, changing at maturity to deep gray or cream. Microscopically, a filament produced both chains of spores, as in *Streptomyces,* and lateral spores, usually in pairs, as in *Micromonospora.* The latter sporulation was scant and transitory in the developmental sequence. These were the most active of the strains studied. Protein and starch breakdown was extreme and rapid, growth was well developed in 24 hours, discoloration and odor production was rapid, and odor was extremely high at 24 hours, decreasing at 7 days.

The three *Nocardia* strains were white and cottony. Like *Streptomyces,* this genus has never previously been reported in American surface water. Fragmentation of the filaments into oblong-curved rod segments began at 48 hours and was complete at 7 days. A musty hay odor was produced throughout the developmental period, never becoming too intense. Agar discoloration was moderate and blackish.

This preliminary survey is being expanded to include a taxonomic study of all forms from the Oklahoma lakes. The major differences noted in these first forms are significant and indicate aquatic actinomycology to be a new and unexplored horizon. The taxonomy of actinomycetes will increase in importance as their role in palatable-water production problems becomes better known.

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Essentials of Distribution System Records

By Frank E. Alderman

A paper presented on Oct. 29, 1952, at the California Section Meeting, Pasadena, Calif., by Frank E. Alderman, Cons. Engr., South Pasadena, Calif.

A WATER system can be operated without adequate distribution system records, but the waste inherent in this practice is tremendous. Moreover, in the event of a real emergency, there may not be time to obtain the information wanted. Not all types of records are essential or even desirable for any given system. Unless the record plays an important function in the operation or management of the system, the time spent in keeping it had better be used to perfect those records which are needed.

In order to set up a system of adequate records, two essential elements must be present: first, the form and extent of the records to be kept must be carefully planned; and second, a procedure must be established and followed to insure the continuance of the records selected.

Distribution system records are not static, and definite procedures to insure that information will flow from the field to the drafting board are a necessary part of record keeping. Probably more records have been lost by waiting for "time to catch up on them" than for any other reason. Either the time never becomes available or, when it does, much of the information has been lost or forgotten. Record posting need not be a daily task, but it should be done regularly and the procedure must be definite.

System Map

One record which is kept by practically all water systems is the system or comprehensive map (*1*). As the name implies, this is a map of the entire system on as large a scale as practicable—usually between 400 and 1,000 ft to the inch—showing all mains, main sizes, valves, hydrants, street names, reservoirs, elevated tanks, wells and other supply sources, booster stations, and emergency interconnections with other systems. If space permits, blowoffs, air release valves, pressure-reducing valves, normally closed gate valves, and any other information pertinent to the overall operation of the system should be included. It is generally preferable, particularly if the scale is small, to omit street lines from this map and to show the larger mains with heavier lines.

The system map should be drawn in ink on tracing cloth, and the original should be carefully stored to preserve and protect it. Blue or black line prints should be used, and, for safety, a negative should be stored separately. A print of this map is usually mounted on the wall in some convenient location for ready reference by all persons concerned with the overall operation of the system.

One of the many uses of the system map, aside from the frequent routine

references which are made to it, is illustrated by this occurrence. One morning the telephone began ringing in the water superintendent's office, and within half an hour a dozen complaints had been logged about fine silt in the water. As the complaints were received from an area several blocks square, it appeared that the source of the trouble might be any of several wells in the vicinity. The system map was then consulted, and a pin was placed at the location of each complaint, with the time of its receipt noted alongside. With this information plotted, it was immediately obvious, from the direction in which the silt was traveling, that one particular well was causing the trouble. This well was taken out of service, and a system of hydrant flushing to clear up the water was determined from the map. Fortunately, such incidents do not occur often, but, when they do, an adequate system map is an indispensable tool.

Sectional Maps

Because the system map must cover the entire system, the scale is necessarily too small to show details. In order to obtain an adequate record it is necessary to divide the system into sections, each of which is then depicted on a separate map, using a scale large enough to show the necessary detail. Probably the most usual scale for sectional maps is 1 in. = 100 ft (1:1,200), with scales as large as 1:600 in congested districts and as small as 1:2,400 in strictly rural areas.

Sectional maps should be drawn in ink on tracing cloth, and great care must be taken to prepare them accurately to scale, so that adjacent sheets will match. In preparing a new set of sectional maps, it is necessary first to obtain all pertinent subdivision maps and record of survey maps and to plot the major controlling points on each sheet from the best available record. Details such as street and lot lines can then be traced from subdivision or other suitable maps which have been enlarged or reduced photostatically to the desired scale. Sectional maps usually contain as much information as can be clearly shown, and, at the scale of 1:1,200, can generally include: lots, blocks, and tracts; street and easement lines; street names and widths; mains, with size, location, material, year installed, and work order number of the installation; fire hydrants, with number and class; valves, with valve number; fittings, with bells and spigots; house numbers; account numbers; service lines, with size, material, length, and location; blowoffs; air release valves; reservoirs; booster stations; wells; tanks; pressure-reducing valves; emergency interconnections with other systems; and any other pertinent information which can be shown without overcrowding. If more than one pressure system is represented, closed valves should be labeled, with the pressure system indicated on each side, and mains should be clearly identified with the system to which they are connected.

In preparing a set of sectional maps for an existing system, it is not always possible to obtain all of the desired information without spending more time than seems justified. In that event, the missing information may be omitted until it can be obtained without undue expense. Sooner or later the line of unknown size or material will be uncovered for repairs or a service connection, and the missing information will be missing no longer. If a map is available for plotting such information

as it is obtained, eventually a poor record will grow into a good one.

As new subdivisions are added to the area, they should be plotted on the map. If the map was accurately laid out originally, these additions should fit in without trouble.

In order to have room to plot all of the necessary information, certain precautions should be observed. House and lot numbers should be kept at the rear of the lot to leave room for service line data; street names should be kept out of the way of future main extensions as much as possible; and symbols should be used instead of labels where feasible. Service line locations are usually indicated by a figure which represents the distance to the nearest street line, the figure being alongside the service on the side toward the street to which the distance is given. Valves can usually be accurately located by giving the distances from two intersecting street lines.

An index map, showing the sheet number of each sectional map, may be prepared from the system map and, if necessary, reduced in size by photostating. Each sheet should have an identification number or number and letter, and the four adjacent matching sheets —one on each side, top, and bottom— should be shown.

Information should be plotted on only one sheet to avoid the necessity of changing more than one sheet when revisions are required.

The sectional maps are among the most important of all water system records. They show the existence and location of considerably more than 75 per cent of the water system property, most of which is underground and cannot be accounted for and located in any other way.

Valve Records

Although most of the information required to locate valves can be shown on the sectional maps, such maps are usually not suitable for use by field crews. The sheets are too large to be carried conveniently, and the information necessary for the field crews can be recorded in more convenient and useful form. Two methods of recording such information are in general use—the "valve plat and list" and the "intersection plat."

The valve list, as the name implies, is a list of all gate valves, together with data pertinent to their location and operation. The complete record consists of small sectional maps of the entire system, usually drawn to a scale of approximately 1 : 6,000, each sheet being of a size convenient to carry in the field in a suitable loose-leaf binder. Each valve on the sheet is numbered and is listed on a page in the same binder. A typical valve plat, showing an area approximately 4,000 ft in each direction, might contain 200 valves, and each sheet in the list might contain 50 valves. As can be seen, this is a very compact record and one which is particularly adapted to field use. The information contained in the list usually includes the number of the valve, the street it is in, the make and size, the number and direction of turns to open, the distance and direction from the principal street line or from the curb, the name of the intersecting street and the distance and direction from its side line or curb, and the use to which the valve is put.

Occasionally an intersection is so complicated, or it is so difficult to locate its property lines on the ground, that the list method is impractical to

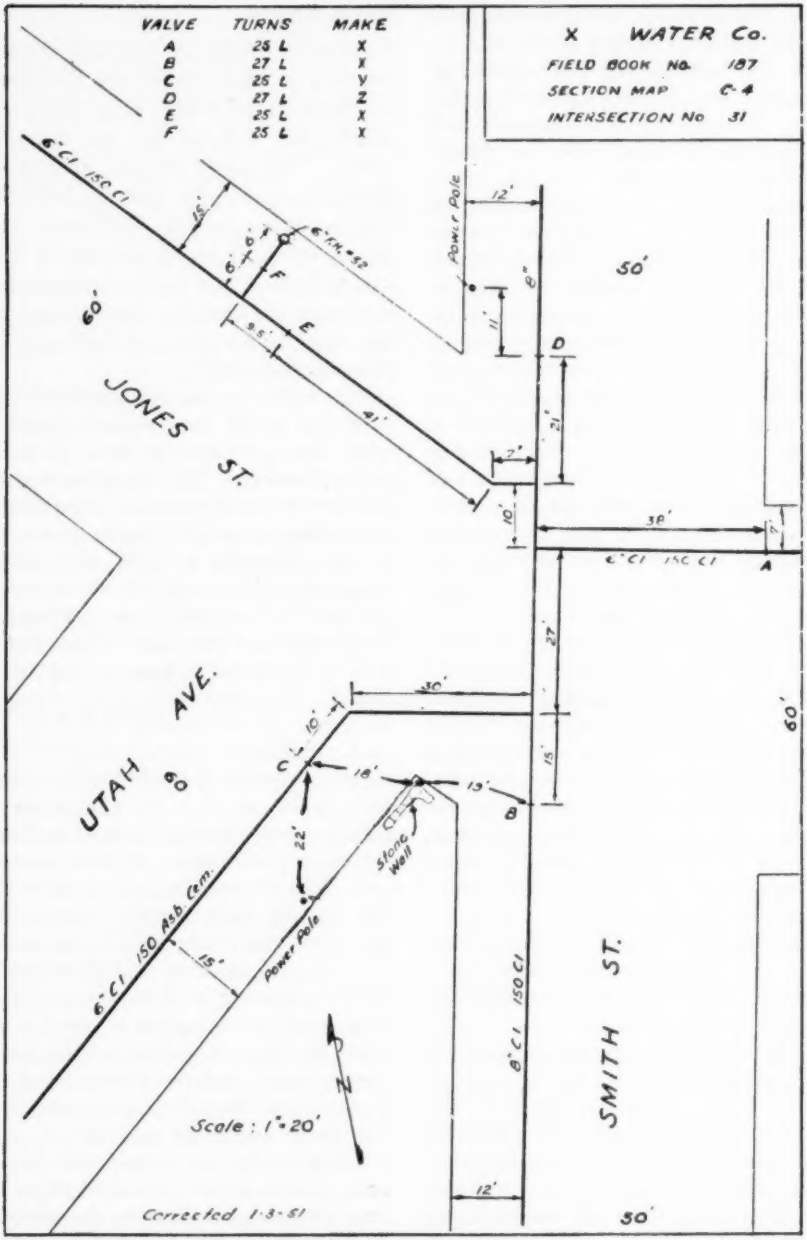

Fig. 1. Intersection Plat

use. The intersection plat should then be used instead. This plat is a map of the individual intersection showing all pipelines, valves, hydrants, and other water works facilities in the intersection. The plat should also show, in addition to street lines, any permanent physical features that may be useful in locating the valves; such landmarks as telephone poles, trees, and house corners should be indicated and used as reference points. A typical example is shown in Fig. 1.

Although it is possible to show more details on the intersection plat than in the valve list, and to refer to objects rather than to property lines, such data are usually unnecessary. The valve list method requires approximately one-tenth as many sheets as the intersection plat method, and, because it is less bulky, it is more likely to be available in the field when needed. For the average system, the list method, with plats of those intersections which require additional detail, would seem ideal.

Card Records

Records of certain items in the distribution system which occur in large numbers, such as services, meters, and fire hydrants, can best be kept on cards. The cards may be either plain or punched, but there is a growing tendency toward the use of the latter (*2*). The punched type has the usual space for writing in the desired information on the body of the card, and, in addition, there are spaces along the four edges which can be punched out to show the same data. For example,

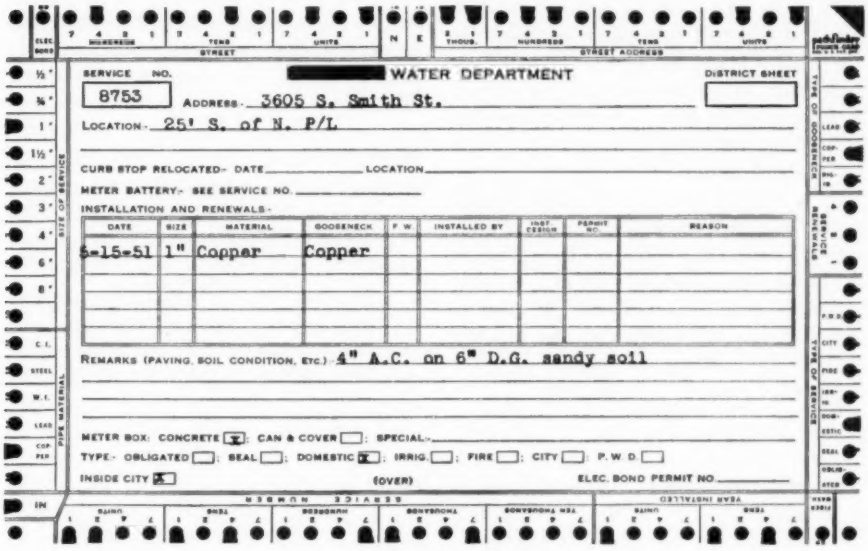

Fig. 2. Punched Record Card

The data typed on the body of the card are also indicated by the punched-out portions along the edges.

numbers representing the size of service may be printed along one side near the edge. Between each number and the edge of the card is a hole. Punching out the remainder of the card between the hole and the edge indicates that the service is of the size shown by the number. If a list of all of the 1½-in. services is desired, the file clerk merely takes a stack of cards and runs a probe through the 1½-in. perforation. The cards for 1½-in. services fall off, and the rest remain in position on the rod. Thus, all services with any particular characteristic can be sorted in a very short time. Street addresses and meter numbers can also be shown by a punch code.

It is well to have a few extra spaces which can be punched to indicate special information. One utility found it desirable to code all meters having stainless steel bolts instead of bronze. All such meters could then be quickly located by sorting the cards. Figure 2 shows a sample record card.

Other Records

The distribution system records discussed are by no means all that are used, but they are the ones most generally employed. Special maps to show ground contours, static pressures or pressure gradients, leakage records, and the like may be desired and can usually be prepared from the maps described. Operation and maintenance records have not been mentioned. Each system will have its own requirements for such records and should keep them in sufficient detail to insure maximum efficiency.

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Perpetual Inventories

By Maurice C. Stout

A paper presented on Sept. 26, 1952, at the Michigan Section Meeting, Battle Creek, Mich., by Maurice C. Stout, Development Engr., Indianapolis Water Co., Indianapolis, Ind.

IN recent years, during periods of critical material shortages, it has become necessary for many utilities to seek more effective methods of inventory control in order to cope with the increased activity in construction and maintenance. Higher demands resulting in increased delay and uncertainty of delivery have necessitated above-normal stock quantities for both construction and maintenance departments. This practice not only adds to ever-mounting carrying costs which eat into profit, but also ties up capital which might be profitably employed elsewhere. Statistics from several large companies which keep accurate cost records show that annual carrying costs are running as high as 18–20 per cent of inventory value. Thus, the utility is faced with the problem of maintaining closer inventory control to keep costs and stocks to a minimum while at the same time providing sufficient quantities to meet construction, maintenance, and emergency demands.

Inefficient inventory control, which could result in interrupted service, makes the water utility more vulnerable to criticism than most other businesses, because public health and safety are involved. Unlike other industries, water utilities cannot offer the very common excuses of strikes, delays, labor shortages, and red tape. The enviable reputation for service continuity which water utilities have earned through efficient management must not be marred by these ever-increasing problems.

All utilities, large or small, should maintain at least a minimum supply of vital materials which can be quickly assembled and rushed to a repair job. A utility with sizable stocks of construction materials for main-laying programs may find ample supplies for emergency use in the distribution system, but for smaller utilities, which do not normally stock materials for main construction, it is most essential that their maintenance supplies be under a control system.

Realizing the great need for maintaining an accurate perpetual inventory, many utilities have adopted the individual-card system of perpetual-inventory control. The old system of bringing the records up to date only once a month will no longer suffice. The perpetual-inventory system is a definite improvement over the old methods and is applicable to the small and large utility alike. A bearing in a pump delivering only 50 gpm is just as vital to its operation as one in a pump producing 50 mgd. The inventory control system may vary in size from a small book containing 25 items to an elaborate system of hundreds of books and thousands of items requiring the use of bookkeeping machines.

It is not necessary for a person to be technically trained in order to operate the system efficiently. The re-

quirements are ordinary intelligence, an understanding of the job, and an interest in the work. Experience has shown that only two or three hours a day are needed for one man to keep the records involving an annual inventory of more than $350,000 in main-laying materials with three or four construction crews continuously installing mains which total approximately 35 miles per year. Certain practices and precautions must be observed, however, to enjoy the full benefits of the system, regardless of the size of the utility.

Need for Coordination

The success of any inventory system is contingent upon the degree of cooperation and coordination among the various departments and personnel involved. Not only should an efficient inventory control system show at a glance the quantity of materials on hand, but it should also give an accurate account of the total investment in materials. Data on interest and overhead charges, overstock of rarely used items which may have resulted from changing conditions and requirements, and other pertinent factors should be readily available.

The system also should serve as a control for buying. Through its application, the quantity of materials to be purchased can be based upon past records of usage and past experience regarding delivery time. Additional factors, such as quality, discounts on quantity buying, transportation charges, and price trends, may be intelligently considered before orders are placed if sufficient notice is available, as it should be when a well-designed perpetual inventory is properly maintained.

The construction and maintenance departments must furnish accurate records of items withdrawn from, returned to, and transferred from stores. The engineering department may sometimes be directly responsible for the records, but it will always find the information on available main-laying materials of value in designing a job. Thus, it is evident that, in a large utility, coordination among the engineering, accounting, and purchasing departments is essential to a successful system of inventory control. The pumping, purification, and distribution departments may also operate their own inventory control system, covering repair parts for their equipment. These departments must also provide accurate information for accounting and purchasing department use. The failure of any one of these departments to do its share of the work can result in an inefficient system or even complete breakdown.

Establishment of System

Experience has demonstrated that the "visible" system of perpetual inventory is very flexible and may be adapted to any utility, large or small. The equipment consists of cards mounted in card pockets, which may be housed in many different ways. The stacks of cards may be kept in single or multiple metal cabinets or mounted on steel tables (either stationary or movable) or on revolving stands. They are often mounted in portable ring binders. Commercial book units are also available (in either imitation leather or metal), which may be kept in single or multiple desk racks or on a swivel stand. The cards are available commercially in many different forms, either single or split, to suit individual needs. Special cards may be secured, but the standard stock forms available are cheaper and more easily replaced. In selecting the equip-

ment, ease of handling and posting, compactness, number of items to be controlled, and convenience of storing should be considered.

The commercial book units, with the multiple desk stand (Fig. 1), are capable of housing any number of books and can be conveniently placed on the corner of a desk, leaving ample room for the handling of individual books. Each book contains space for 100 controlled items. If the number of items to be controlled requires the use of more than three books, however, the

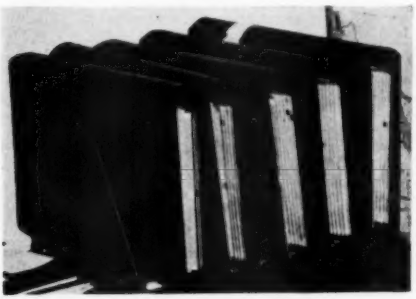

Fig. 1. Book Units in Desk Stand

A divider plate, like the one shown on the end, is provided between books. The rack may be extended to accommodate additional books merely by bolting on the desired number of sections.

advantages of the metal cabinet should not be overlooked, as it may offer additional convenience in handling for approximately the same initial investment. Incidentally, the books shown in Fig. 1, with a supply of cards sufficient for controlling approximately 500 items, cost less than $150 in 1951.

In the system in use at Indianapolis to control main-laying materials, a separate card is used for each item. For positive identification, it is essential that each item have a stock number assigned to it, as several brands of the same item may be stocked. Further, when the cards have been filled and are removed from the card pocket, for permanent filing, the stock number will be the only identifying mark. The general description of the item is typed on the card pocket rather than on the card, thus eliminating the retyping of the description when a new card is installed (Fig. 2).

The card pocket has a lower and upper section, both of which are allocated to the same item. The upper section contains two 4 × 5-in. cards. One shows the record of orders, including such information as date, quantity, amount received, and balance on order. The other card shows the cost per unit and usage by months, with space for 7 years of record. This record allows the establishment of a clear buying pattern which can be relied upon for determining both current and future needs. The lower section of the pocket contains a card for daily entries of receipts and withdrawals, including the date and order number. Also shown are the minimum and maximum amounts of the item to be carried in stock. All cards are printed on both sides for double life.

Control for Buying

The minimum stores to be carried cannot be accurately established until at least a year's experience makes it possible to determine a definite pattern of usage. During the first year or so it will be necessary to operate on a trial and error basis, and some overages and shortages will no doubt occur. An approximate minimum may be determined from a long-range average of usage between the last two physical inventories, after correcting for all receipts. Once the approximate monthly usage is established, the minimum stores can be determined by multiplying the average monthly usage by the

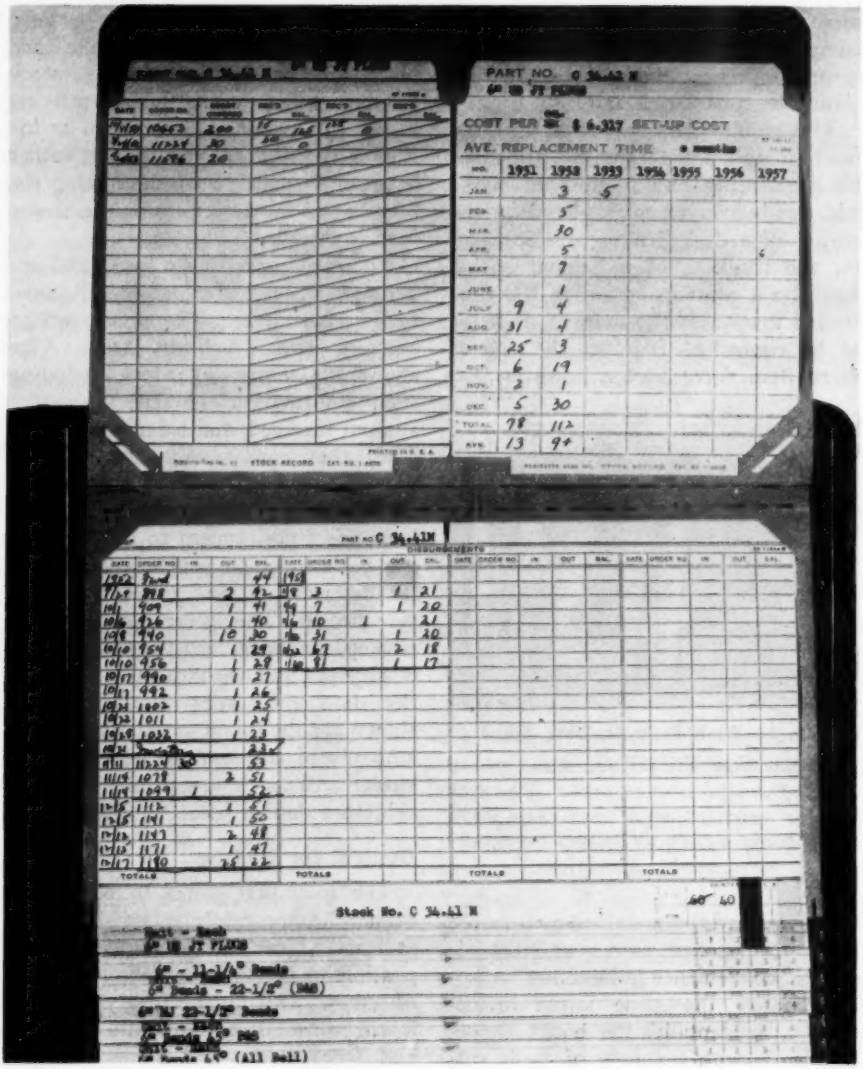

Fig. 2. Inventory Card File

The cards are housed in the book units shown in Fig. 1. The colored signal tab in the lower right-hand corner indicates that the quantity of the item in stock is below the minimum desirable.

approximate delivery time in months. As this procedure would allow the stores to reach zero by the time the new shipment was received, it is suggested that the computed minimum be increased by at least one month's usage, to allow for unforeseen contingencies and to maintain a safe supply.

Because all items will obviously not reach their minimum simultaneously, the extra month's supply will also allow the entry of individual items on the want list, which can be held for a short time until several items can be grouped into an order of sufficient size to avoid shipping problems. For main-laying materials, it may be advisable to set up the system so that fittings can be shipped along with pipe in carload lots, to keep freight costs to a minimum.

One of the most desirable features of this system is its unlimited flexibility of operation, which permits the utility to establish the most desirable buying pattern. It is very important, however, to prepare summaries of usage at frequent intervals. It may be necessary to summarize some items monthly but others less often, depending upon the usage.

The maximum number of items to be carried in stores will depend on the rate of usage and the practical frequency of placing orders. The remaining length of the current main-laying season may also dictate the maximum quantity of materials to buy, as it may not be desirable to have large stocks on hand during the winter. Quantity discounts, price trends, and other factors must not be overlooked when making this decision.

Colored Signals

At the lower right-hand corner of the lower card section previously described, space is provided to insert colored signals. Various colors may be used to indicate the desired information. For example, a green signal may show that the stock of an item has reached its minimum. A red signal may denote that the item is completely out of stock. A yellow signal can be inserted in one position when an order is placed and shifted to another location after the shipping notice has been received. Other signals are available to denote such information as normal supply, overstock of item, follow-up on orders, and similar useful data. These signals are visible at a glance even when the card pockets are closed, making it unnecessary to thumb through countless pages to check the necessity for ordering or following up.

Receipt of Materials

Important to the success of any system is an accurate check on the receipt of new materials. Each shipment should be carefully checked and compared with the shipping notice as soon after receipt as possible. If a discrepancy appears, it should be looked into immediately and sufficient information recorded to allow the filing of a claim for the missing materials, if any. Only the materials received should be placed on the records. Delays in reconciling discrepancies magnify the problem, as items may be removed from or returned to stores during the interim.

Reconciliation of Each Job

When materials are withdrawn from storage for use on a construction or maintenance job, delivery tickets should be filled out. The ticket should carry a previously assigned job number, which can be posted along with the quantity of each item removed from stores. In the larger utilities, a copy should be sent to the accounting department for posting of job costs. When the job is completed, the materials actually used should be promptly reported and reconciled against the delivery tickets. If unused materials are returned to stores or transferred to another job, appropriate tickets should be turned in.

It is urgent that this reconciliation be made promptly after a job has been completed in order that memories will be fresh enough to clear up any discrepancy which might appear. It must be emphasized that the perpetual-inventory system is only as accurate as the personnel who keep the records and report the data. If the "check-as-you-go" plan is followed, there is little likelihood that large errors will creep into the records. Instructing the personnel on the classification of materials further reduces the chance for error, especially when several brands of one item are stocked.

An error which is commonly made is the improper identification of pipe bends. For example, the inexperienced worker's conception of a 22½- and an 11¼-deg bend may be very nearly the same, especially when viewed separately. Some distribution systems now have both bell-and-spigot and mechanical-joint pipe, which often necessitates the use of both types on a single job. The delivery tickets must, therefore, accurately show the type of material as well as the quantity. Improper classification will often make the job of reconciling material records extremely difficult and time consuming. Care must be exercised in choosing personnel for this kind of work. They must be efficient, alert, and familiar with the items carried in stock.

Small-Parts Inventory

The discussion up to this point has dealt principally with the larger items used in distribution system construction and maintenance. Numerous small items, such as pipe fittings, bolts, nuts, washers, gasket material, small tools, repair parts for mechanical equipment, and countless other materials are also used around the plant and in the field. Some of these items are normally carried in trucks and cars, while others may be stored in bins. Those which are not in constant demand may be stored by other means. Some parts may be stocked for very rare emergencies in quantities of only one or two, yet these parts are often at least as essential as the more common items carried in large quantities. The rarely used materials are the ones which are soon forgotten, and often considerable commotion is caused when they cannot be found. The individual-card system of perpetual inventory is also adaptable to this type of control problem.

Repair parts which can be obtained locally, and which may be needed only at intervals of two or three years or longer, may not have to be stocked at all. Except in emergencies, they can be ordered in advance of the repair job when routine inspection of equipment indicates the need. A perpetual-maintenance log will be useful in anticipating repetitive maintenance. The record of all repairs made on a certain piece of equipment, including the dates, will be readily available for annual review. Orders may be placed for the needed materials well ahead of the scheduled overhaul job.

A bin tag is in reality a simplified form of perpetual-inventory record kept adjacent to the material. The bins and bin tags carry a stock number. The stock man, as he receives or withdraws material, enters the item in the "in" or "out" column and corrects the balance on hand. An advantage of the bin tag is that the accuracy of the stock man's work may be verified at any time. It is also an easy matter to count what is in the bin when the stock is reduced to a small quantity. Each time this is done, the information may be recorded on the tag as an "inventory" and the balance for-

warded to a new tag. The old tag can then be checked against the book record.

Each time an item is withdrawn from stock, a ticket should be made out listing the quantity and the job for which it is intended. The person making the withdrawal should be required to sign the ticket. Similar records may be kept for items returned to stores. Once a day the tickets should be turned in for posting in a card control system such as that previously described. Showing location for each item carried on the card facilitates the finding of articles. Where large quantities of repair parts are stocked, it may sometimes be necessary to use a cross-index to identify the parts by stock number. This index will also make it easier to find rarely used items.

In a large utility where bin cards are used, when an item has reached its minimum, it may be advisable to place the responsibility of preparing purchase requisitions for new materials on the storekeeper. If this system is practiced, immediate action should be taken by whoever must authorize the purchase, as delay may cause a serious reduction in the dwindling supply.

Physical Inventory

Were every transaction correctly entered, there would be no occasion to take a physical count, as the book inventory would suffice. It would be unwise, however, to assume such a degree of accuracy. The records must be verified to prevent possible cumulative errors and discrepancies. The difficulties of getting an accurate count when materials are constantly entering and leaving the storeroom or pipeyard are considerable. If possible, arrangements should be made to take inventory during a period when use is at a minimum, or even during an off period.

The frequency of physical inventory will vary with the usage of the particular item. An advantage of the perpetual-inventory system is that the physical count may be spread out over a considerable period of time. A few items can be checked one week and more the next, if desirable. It may be necessary, however, to take a complete physical inventory at least once a year.

The method of making the count will depend on the item in question. It may be practical to weigh some articles, having previously determined the number of items per unit of weight. Others may be measured by pouring them into a container of known capacity. The bulk of the items, however, will have to be counted piece by piece for a high degree of accuracy.

In comparing the inventory count with the records, it is essential that all posting be up to date. Should a major discrepancy appear, a recount of the questionable items may be necessary. If this does not clear up the discrepancy, the cause of the error should be carefully analyzed and steps taken to prevent repetition. It is often necessary to correct the records to agree with the physical count, but this will not ordinarily involve sizable quantities of material if care is exercised in maintaining accurate records.

It is recognized that the perpetual-inventory system offers less opportunity for dishonesty than other systems. When records are kept in good shape and the personnel are well trained and disciplined, it is generally accepted that considerably more than 99 per cent agreement can be obtained between book inventory and physical count. Occasional spot checks during the course of a year on items commonly used will assure greater accuracy. It is often easy to overlook materials in transit, not yet shelved, or loaned out.

The general condition of the storage bins and storage yard will greatly affect the accuracy of the count. When articles are stored out of doors, care should be taken to keep pieces of like size and kind segregated. If a yardman or stores clerk is not always on the job and inexperienced workers or truck drivers return items to stores, it may occasionally be necessary to regroup the articles, especially prior to taking inventory.

The storeroom should be large enough to allow orderly storage of all materials so that they are readily accessible and easily inventoried. A central storage point is advisable, because better supervision and service can be provided in one large storeroom than in several decentralized ones.

Where the arrangement will permit, materials should be stored as near as possible to the point of use. Material can sometimes be issued in bulk to another department and placed in its direct custody. This is particularly advisable if the quantities issued are not large enough to justify a separate storeroom.

Proper atmospheric conditions are essential to the protection of the materials. Rarely used items should occasionally be inspected to avert the possibility of finding them unusable when they are needed for emergency use. Inventory records may show accurate quantities, but they reveal little or nothing of the general condition of the material. This is an important part of the storekeeper's and yardman's responsibility, as an item unfit for use is of no value and should not be carried on the records.

Continuing Property Records

Some utilities have recently established continuing property records. These records are in reality a perpetual inventory of all the utility's holdings. All structures, land, and equipment are carried at original cost, with all capital additions and retirements posted annually.

Such records have many advantages. The current value of the utility's holdings can be calculated at any time by applying a factor to the original cost. This practice considerably reduces the amount of preparatory work involved in the unpleasant but necessary task of furnishing substantiating evidence to support a request for a rate increase. If the utility is privately owned and its holdings are spread out over several townships where different tax rates prevail, the information is valuable in computing and checking the total amount of the taxes. When parts of the distribution system or pieces of mechanical equipment are retired, the necessity for making cost estimates for the retired items is completely eliminated. Assistance in setting up such a system may be readily secured from consultants who specialize in this field.

This paper by no means covers all the requirements for establishing and operating a perpetual-inventory system. Some details will have to be worked out to suit the individual circumstances. The author has attempted to discuss only the essential factors involved, based on experience gained from the use of perpetual-inventory control of main-laying materials. Further information can be found in the literature (*1*). Assistance in setting up a system may also be secured from manufacturers of the equipment or materials involved.

Reference

1. GRUNDY, J. A. Utility Inventory Control by Visible Record System. *Wtr. & Sew. Works*, **99**:356 (Sept. 1952).

UDC 621.774.1

ASA A21.11-1953
(AWWA C111-53)

American Standard Specifications

for

A MECHANICAL JOINT FOR CAST IRON PRESSURE PIPE AND FITTINGS

PUBLISHED BY AMERICAN WATER WORKS ASSOCIATION, INC.

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Approved by American Standards Association Jan. 13, 1953

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UDC 621.774.1

ASA A21.11-1953
(AWWA C111-53)

American Standard Specifications for

A Mechanical Joint for Cast Iron Pressure Pipe and Fittings

This specification covers a mechanical joint, in sizes 3 in. to 48 in., for cast iron pressure pipe made by pit cast or by centrifugal methods and cast iron pressure fittings, for gas, water, and other liquids.

Sec. 11-1—Definitions

Purchaser. Wherever the word "purchaser" is used herein, it shall be understood to mean the actual purchaser of the pipe or his authorized agents acting within the scope of the duties entrusted to them.

Manufacturer. The word "manufacturer" means the producer who is making the pipe or fittings and who assumes the responsibility for the fulfillment of these specifications. Accessories, including glands and bolts, may be sublet to other manufacturers. Gaskets will in general be made by other manufacturers who are not expected to permit inspection of manufacturing processes without special arrangements.

Sec. 11-2—Description of Joint

The mechanical joint is a bolted joint of the stuffing-box type, as shown in Fig. 11.1. Each joint shall consist of: [1] a bell cast integrally with the pipe or fitting and provided with an exterior flange having cored or drilled bolt holes and interior annular recesses for the sealing gasket and the spigot of the pipe or fitting; [2] a pipe or fitting spigot; [3] a sealing gasket; [4] a separate cast iron follower gland having cored or drilled bolt holes; and [5] cast iron tee-head bolts and hexagon nuts.

The joint is designed to permit normal expansion, contraction, and deflection of the pipeline.

Sec. 11-3—Pipe and Fittings to Which Mechanical Joint Is Applicable

The mechanical joint made under these specifications is intended for use on cast iron pressure pipe and fittings made in accordance with the following ASA standard specifications and shall be suitable for leakproof assembly therewith:

ASA A21.2 (AWWA C102)—Specifications for Cast Iron Pit Cast Pipe for Water or Other Liquids

ASA A21.3—Specifications for Cast Iron Pit Cast Pipe for Gas

ASA A21.6 (AWWA C106)—Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds, for Water or Other Liquids

ASA A21.7—Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds, for Gas

ASA A21.8 (AWWA C108)—Specifications for Cast Iron Pipe Centrifugally Cast in Sand-lined Molds, for Water or Other Liquids

ASA A21.9—Specifications for Cast Iron Pipe Centrifugally Cast in Sand-lined Molds, for Gas

ASA A21.10 (AWWA C110)—Specifications for Short-Body Cast Iron Fittings, 3 Inch to 12 Inch, for 250-psi Water Pressure Plus Water Hammer.

The mechanical joint shall meet all applicable requirements of the above listed specifications and shall have the same pressure rating as the pipe or fitting of which it is a part.

Mechanical joints for pipe or fittings beyond the scope of such standard specifications shall be subject to agreement between the manufacturer and the purchaser.

Sec. 11–4—Dimensions and Tolerances

The joint and accessories shall meet the dimensions and the tolerances shown above them in Table 11.1.

Sec. 11–5—Bell and Socket

The bell shall be cast integrally with the pipe or fitting and shall meet the applicable requirements of the specification under which the pipe or fitting is produced.

The surfaces of the bell and socket shall be smooth and free from holes, laps, and defects of every nature which unfit them for the use for which they are intended. The bell and socket shall be subject to suitable joint tests for leakage. Such tests shall be made at sufficiently frequent intervals to assure that the joints will be tight when properly assembled.

The annular recesses of the socket, the bolt circle, and the bell flange shall be concentric within the tolerances of Table 11.1. The dimensions of the bell and socket, the bolt circle, and the spacing of the bolt holes shall be gaged in accordance with Table 11.1, at sufficiently frequent intervals to assure dimensional control.

Sec. 11–6—Glands

The iron in the glands shall meet the requirements of Class 25 of Standard Specifications for Gray Iron Castings —ASA G25.1 (ASTM A48). The preferred acceptance test under this specification shall be the transverse test, although the tension test may be used for qualification. The minimum strengths under this specification are shown in the following table:

	1.2-in. Diam. Bar, 18-in. Supports, Load at Center	2-in. Diam. Bar, 24-in. Supprots, Load at Center
Minimum transverse breaking loads.....	2,000 lb	6,800 lb
Minimum tensile strength.....	25,000 psi	

The annular surfaces of the gland lip and the bolt circle shall be concentric. Their accuracy within the tolerances of Table 11.1 shall be checked by gaging at sufficiently frequent intervals to assure dimensional control.

The surfaces of the gland shall be smooth and free from defects of every nature which would unfit them for the use intended.

Glands shall be coated with a bituminous dip or paint unless otherwise specified.

Sec. 11–7—Bolt Holes

Bolt holes for pipe and fittings may be drilled or cored. All bolt holes shall be free of sand or projections of iron that would interfere with the fit of the bolts. Drilled holes shall be

gaged as to location, at sufficiently frequent intervals to assure dimensional control. All cored holes shall be gaged for diameter of bolt circle, location and size of holes, and concentricity with the socket or gland lip.

Sec. 11–8—Gaskets

Manufacture. The gasket shall be made of a vulcanized crude-rubber compound and, unless otherwise specified, the rubber shall be first-grade plantation rubber. All surfaces of the gaskets shall be smooth except for the specified marking, and free from imperfections, and the gaskets shall be free from any porosity. Tips or backs, if specified for special conditions, shall be applied as shown in Fig. 11.2 and shall be well bonded to the rubber.

Service. Plain rubber gaskets are standard for joints in water service or other service where the gas or liquid being conveyed or the temperature is not deteriorating to the gaskets. Tips of duck, thiokol-impregnated duck, synthetic rubber of various kinds, lead, and other materials can be applied for special services. Duck or other reinforcing material also may be applied to the back of the gaskets. Gaskets other than plain rubber shall be specified on the purchase order.

Physical Properties and Tests. The following tests shall be made by the gasket manufacturer in accordance with Federal Specification ZZ–R–601a or the equivalent ASTM specification. The test specimen for all tests except hardness shall be die cut from routine production gaskets. It shall have a gage length of 2 in. with a width of 0.25 in. and a thickness of 0.10 in. The gaskets selected for testing shall be such as to represent the full range of quality of the lot from which the order is to be filled. For each 5,000 gaskets produced or for any week's production of less than 5,000 gaskets, at least one set of tests shall be made:

1. Ultimate tensile strength
2. Ultimate elongation
3. Elongation at 1,000-psi stress—limits: 110–190 per cent
4. Permanent set—the sample shall be clamped for 10 min at the elongation produced by 1,000-psi stress, relieved of load, and measured after 10 min rest; the permanent set, expressed as a percentage of the original gage length, shall not exceed 5 per cent
5. Hardness—hardness tests shall be made on each batch of production gaskets; this test shall be made with a Type A durometer; the preferred hardness is 70–75 durometer.

Sec. 11–9—Bolts and Nuts

High-strength, heat-treated cast iron tee-head bolts with hexagon nuts shall be the standard bolts; they shall be in accordance with Fig. 11.3 and meet the requirements hereinafter specified. If special types of bolts are required by the purchaser, agreement as to such shall be made at the time of placing the order.

Standard bolts and nuts shall be manufactured under close metallurgical control, and the finished bolt and nut assemblies shall be subject to proof testing with the load applied between the head and the nut in a suitable test machine. Proof tests shall be made at sufficiently frequent intervals to assure conformance with the proof test loads. The following proof test loads shall be applicable and shall not permanently stretch the bolt:

Size *in.*	Proof Test Load *lb*
⅝	10,000
¾	15,000
1	24,500
1¼	40,000

The bearing surface of the cast nut shall be smooth, and the nut shall be tapped at right angles to this surface to insure axial loading.

Bolts and nuts shall be coated with a rust-preventing lubricant after threading or tapping. They shall be packed in suitable containers, which shall be marked with the number of bolts, the size and type of bolts, and the net weight.

Sec. 11–10—Foundry Records

A record of the specified tests, including those of glands, bolts, and gaskets, shall be made and retained for at least one year. Upon request, such records will be available to the purchaser at the foundry. If written transcripts of the results of any tests are desired, this fact shall be noted in the order for the material.

Sec. 11–11—Inspection by Purchaser

(a) The purchaser shall have access at all times to those parts of the manufacturer's plant which concern the manufacture of articles being made for him. If the purchaser desires to inspect the manufacture of glands, bolts, and gaskets which may be made by subcontractors, special arrangements must be made therefor at the time of placing the order. He may inspect the joint material and may reject any of the material which is not in conformity with the specification.

(b) The manufacturer shall provide all tools, testing equipment, materials, labor, and facilities necessary for the required testing and inspection of the joint at the foundry.

(c) The purchaser shall make written report daily to the foundry office of all material rejected, with the causes for rejection.

Sec. 11–12—Inspection and Certification by Manufacturer

Should the purchaser have no inspector at the works, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the inspection and all of the tests have been made and met as specified.

Notes on Method of Installation

These notes are not parts of the Standard, but are given for information only.

The successful operation of the mechanical joint specified requires that the spigot be centrally located in the bell and that adequate anchorage shall be provided where abrupt changes in direction and dead ends occur.

The rubber gasket seals most effectively (particularly when sealing gas) if the surfaces with which it comes in contact are brushed thoroughly with a wire brush just prior to assembly. This thorough brushing removes all loose rust or foreign material which may be present and provides clean surfaces which should be brushed with soapy water just prior to slipping the gasket over the spigot end

and into the bell. Soapy water brushed over the gasket prior to installation also removes loose dirt and lubricates the gasket as it is forced into its retaining space.

For water and gas service, the normal range of bolt torques to be applied to standard cast iron bolts in a joint are:

Size *in.*	Range of Torque *ft-lb*
$\frac{5}{8}$	40– 60
$\frac{3}{4}$	60– 90
1	70–100
$1\frac{1}{4}$	90–120

The above torque loads may be applied with torque measuring or indicating wrenches. Torque wrenches may be used to check the application of approximate torque loads applied by men trained to give an average pull on a definite length of regular socket wrench. The following lengths of wrenches should satisfactorily produce the above ranges of torques when used by the average man:

Size *in.*	Length of Wrench *in.*
$\frac{5}{8}$	8
$\frac{3}{4}$	10
1	12
$1\frac{1}{4}$	14

When tightening bolts, it is essential that the gland be brought up toward the pipe flange evenly, maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. This may be done by partially tightening the bottom bolt first, then the top bolt, next the bolts at either side, and last, the remaining bolts. Repeat this cycle until all bolts are within the above range of torques. If effective sealing is not attained at the maximum torque indicated above, the joint should be disassembled and reassembled after thorough cleaning. Overstressing of bolts to compensate for poor installation practice is to be avoided.

TABLE 11.1—*Mechanical-Joint Dimensions, in Inches*

Size	A	B	C	D	F	θ	X	J	K_1		K_2	L	M	O	P	S		Bolts		
									Centrifugal Pipe	Pit Cast Pipe and Fittings						Centrifugal Pipe	Pit Cast Pipe and Fittings	No.	Size	Length
3	±.06 3.96	2.50	±.04 4.84	+.06 −.04 4.94	+.07 −.03 4.06	28°	+.06 −.0 ¾	±.06 6.19	−.06 7.62	−.12 7.69	−.12 7.69	−.06 .94	−.06 .62	.31	.63	−.05 .47	−.10 .52	4	¾	3
4	±.06 4.80	2.50	±.04 5.92	+.06 −.04 6.02	+.07 −.03 4.90	28°	+.06 −.0 ⅞	±.06 7.50	−.06 9.06	−.12 9.12	−.12 9.12	−.06 1.00	−.06 .75	.31	.75	−.05 .55	−.10 .65	4	¾	3½
6	±.06 6.90	2.50	±.04 8.02	+.06 −.04 8.12	+.07 −.03 7.00	28°	+.06 −.0 ⅞	±.06 9.50	−.06 11.06	−.12 11.12	−.12 11.12	−.06 1.06	−.06 .88	.31	.75	−.05 .60	−.10 .70	6	¾	3½
8	±.06 9.05	2.50	±.04 10.17	+.06 −.04 10.27	+.07 −.03 9.15	28°	+.06 −.0 ⅞	±.06 11.75	−.06 13.31	−.12 13.37	−.12 13.37	−.08 1.12	−.08 1.00	.31	.75	−.05 .66	−.12 .75	6	¾	4
10	±.06 11.10	2.50	+.06 −.04 12.22	+.06 −.04 12.34	+.07 −.03 11.20	28°	+.06 −.0 ⅞	±.06 14.00	−.06 15.62	−.12 15.69	−.12 15.62	−.08 1.19	−.08 1.00	.31	.75	−.06 .72	−.12 .80	8	¾	4
12	±.06 13.20	2.50	+.06 −.04 14.32	+.06 −.04 14.44	+.07 −.03 13.30	28°	+.06 −.0 ⅞	±.06 16.25	−.06 17.88	−.12 17.94	−.12 17.88	−.08 1.25	−.08 1.00	.31	.75	−.06 .79	−.12 .85	8	¾	4
14	+.05 −.08 15.30	3.50	+.07 −.05 16.40	+.07 −.05 16.54	+.06 −.07 15.44	28°	+.06 −.0 ⅞	±.06 18.75	−.08 20.25	−.12 20.31	−.12 20.25	−.12 1.31	−.12 1.25	.31	.75	−.08 .85	−.12 .89	10	¾	4
16	+.05 −.08 17.40	3.50	+.07 −.05 18.50	+.07 −.05 18.64	+.06 −.07 17.54	28°	+.06 −.0 ⅞	±.06 21.00	−.08 22.50	−.12 22.56	−.12 22.50	−.12 1.38	−.12 1.31	.31	.75	−.08 .91	−.12 .97	12	¾	4½
18	+.05 −.08 19.50	3.50	+.07 −.05 20.60	+.07 −.05 20.74	+.06 −.07 19.64	28°	+.06 −.0 ⅞	±.06 23.25	−.08 24.75	−.15 24.83	−.15 24.75	−.12 1.44	−.12 1.38	.31	.75	−.08 .97	−.15 1.05	12	¾	4½
20	+.05 −.08 21.60	3.50	+.07 −.05 22.70	+.07 −.05 22.84	+.06 −.07 21.74	28°	+.06 −.0 ⅞	±.06 25.50	−.08 27.00	−.15 27.08	−.15 27.00	−.12 1.50	−.12 1.44	.31	.75	−.08 1.03	−.15 1.12	14	¾	4½
24	+.05 −.08 25.80	3.50	+.07 −.05 26.90	+.07 −.05 27.04	+.06 −.07 25.94	28°	+.06 −.0 ⅞	±.06 30.00	−.08 31.50	−.15 31.58	−.15 31.50	−.12 1.62	−.12 1.56	.31	.75	−.08 1.08	−.15 1.22	16	¾	5
30*	32.00	4.00	33.29	33.46	32.17	20°	1¼	36.88	39.12	39.12	39.12	1.81	2.00	.38	1.00	1.20	1.50	20	1	5½
36*	38.30	4.00	39.59	39.76	38.47	20°	1¼	43.75	46.00	46.00	46.00	2.00	2.00	.38	1.00	1.35	1.80	24	1	5½
42*	44.50	4.00	45.79	45.96	44.67	20°	1¼	50.62	53.12	53.12	53.12	2.00	2.00	.38	1.00	1.48	1.95	28	1¼	6
48*	50.80	4.00	52.09	52.26	50.97	20°	1¾	57.50	60.00	60.00	60.00	2.00	2.00	.38	1.00	1.61	2.20	32	1¼	6

* Dimensions are tentative for these sizes.

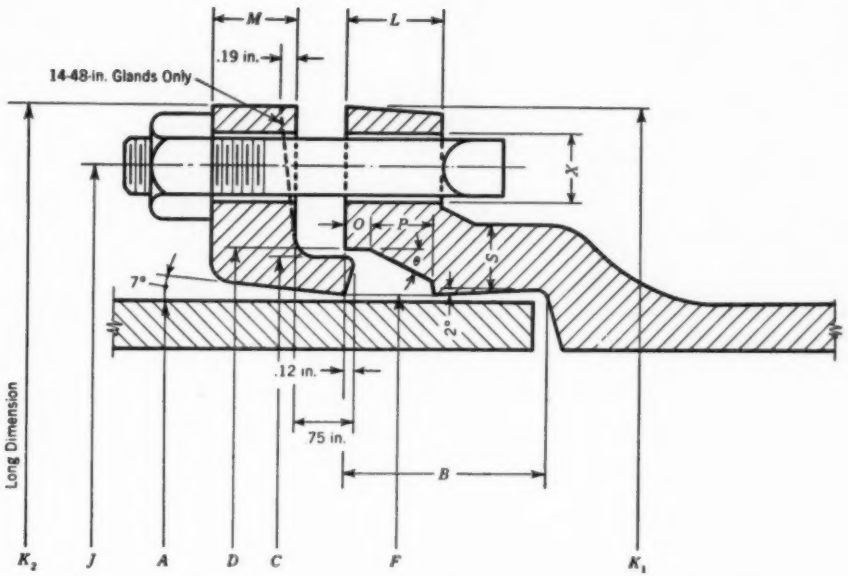


Fig. 11.1. 3–48-in. Standard Mechanical-Joint Dimensions (See Table 11.1)

Notes

1. The thickness of the bell, S, shall in all instances be equal to, and generally exceeds by at least 10 per cent, the nominal wall thickness of the pipe or fitting of which it is a part.

2. Cored holes may be tapered an additional 0.06 in. in diameter.

3. In the event of ovalness of the spigot OD, the mean diameter measured by a circumferential tape shall not be less than the minimum diameter shown in the table. The minor axis shall not be less than the above minimum diameter plus an additional minus tolerance of 0.04 in. for sizes 8–12 in., and 0.07 in. for sizes 14–24 in.

4. K_2 is OD of glands across bolt holes; outside of gland may be polygon shape.

5. Dimensions of 30–48-in. sizes are tentative.

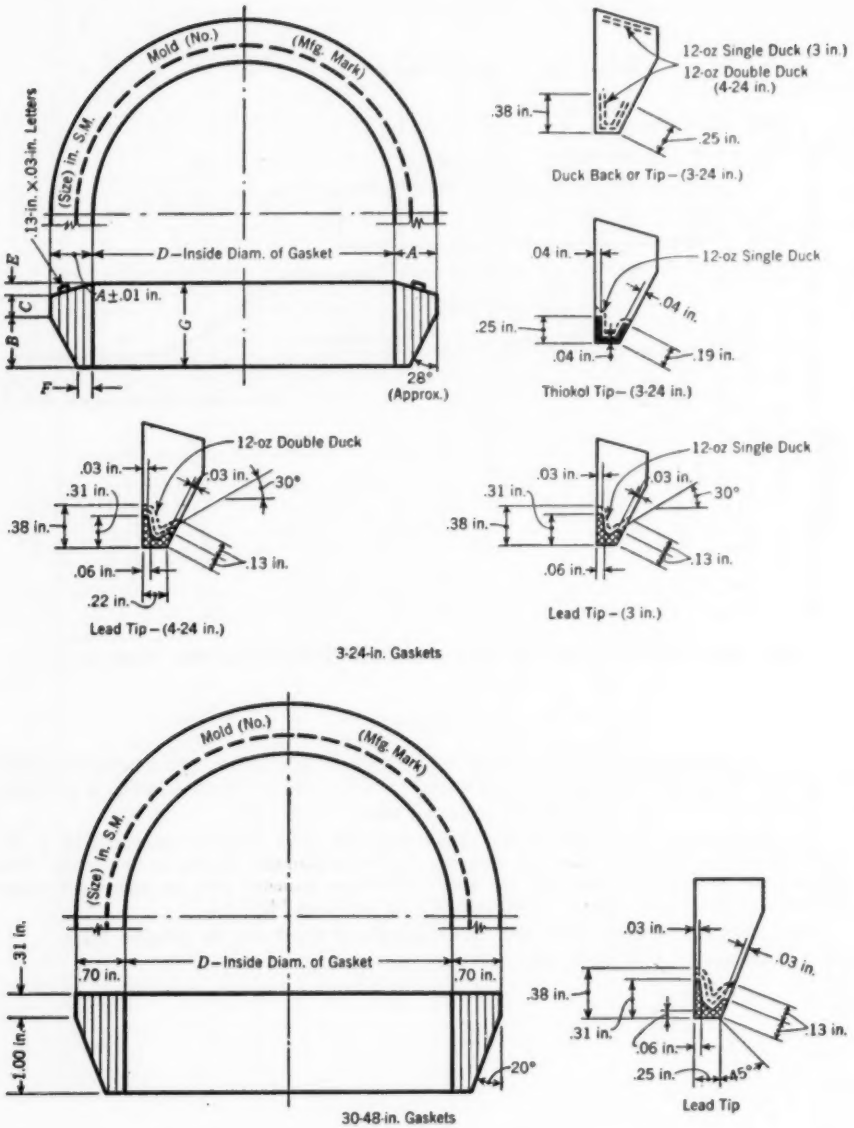


Fig. 11.2. Mechanical-Joint Gaskets (See Table 11.2 and Notes)

TABLE 11.2

3–48-in. Mechanical-Joint Gasket Dimensions, in Inches

Pipe Size	Pipe OD	Dimensions of Plain Rubber Gaskets						
		A ±.01 in.	*B*	*C*	*D* +0% −1%	*E*	*F* ±.01 in.	*G* ±.02 in.
3	3.96	.48	.62	.31	3.90	.12	.15	1.05
4	4.80	.62	.75	.31	4.73	.16	.22	1.22
6	6.90	.62	.75	.31	6.80	.16	.22	1.22
8	9.05	.62	.75	.31	8.91	.16	.22	1.22
10	11.10	.62	.75	.31	10.93	.16	.22	1.22
12	13.20	.62	.75	.31	13.00	.16	.22	1.22
14	15.30	.62	.75	.31	15.07	.16	.22	1.22
16	17.40	.62	.75	.31	17.14	.16	.22	1.22
18	19.50	.62	.75	.31	19.21	.16	.22	1.22
20	21.60	.62	.75	.31	21.28	.16	.22	1.22
24	25.80	.62	.75	.31	25.41	.16	.22	1.22
30*	32.00				31.50			
36*	38.30				37.62			
42*	44.50				43.67			
48*	50.80				49.80			

* Dimensions are tentative for these sizes.

Notes

1. Duck backing can be omitted from lead-tipped gaskets provided sufficient bonding of the lead to the rubber is obtained.
2. Tipped or backed gaskets may be made in the same mold as plain rubber gaskets, but the inside diameter of such reinforced portions shall not exceed the "Pipe OD."
3. Dimensions of 30–48-in. sizes are tentative.

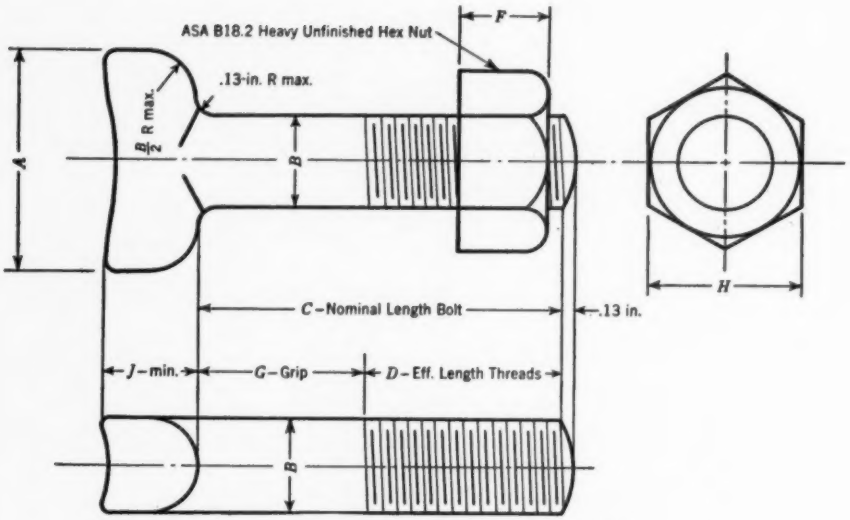


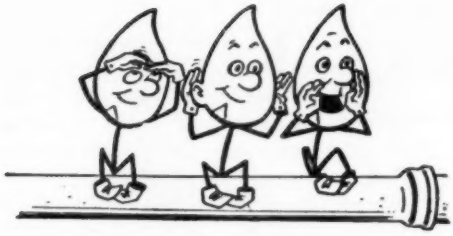
Fig. 11.3. Mechanical-Joint Bolts and Nuts

TABLE 11.3

Mechanical-Joint Bolt and Nut Dimensions, in Inches

Nom. Size	*A* ±.12	*B* ±.03	*C* ±.12	*D* +unlim. −.06	*E**	*F* +.12 −.00	*G*	*H*†	*J*	Weight of 100 Bolts With Nuts *lb*
⅝×3	1.50	.625	3.00	1.50	11	.625	1.50	1.062	.625	47
¾×3½	1.75	.75	3.50	2.00	10	.75	1.50	1.25	.75	77
¾×4	1.75	.75	4.00	2.00	10	.75	2.00	1.25	.75	82
¾×4½	1.75	.75	4.50	2.00	10	.75	2.50	1.25	.75	87
¾×5	1.75	.75	5.00	2.00	10	.75	3.00	1.25	.75	93
1 ×5½	2.25	1.00	5.50	2.50	8	1.00	3.00	1.625	1.00	192
1¼×6	2.50	1.25	6.00	2.50	7	1.25	3.50	2.00	1.25	334

* Standard threads per inch, coarse-thread series, Class 2 fittings (ASA B1.1).
† Tolerance—for ⅝-in.: +0.0, −0.04; ¾-in.: +0.0, −0.06; 1-in.: +0.0, −0.08; 1¼-in.: +0.0, −0.10 in.



Percolation and Runoff

Grand Rapids practically ahoy! And a real jam session it will be that AWWA brings to town. Jammed already are the hotel facilities, jammed for sure will be the technical sessions, and no less jammed will be an entertainment program that will even bring Paul Bunyan out of the woods. Jammed full of information and fun, that is, with Michigan's unexcelled hospitalitarians doing their jammedest to make this the biggest, the best, and certainly the Grandest convention ever. To see why, take a squint at the program outlined on P&R pages 86–90.

The super-Hooper rating of years past, which measured the popularity of radio programs by the plunge in water pressure following each show, has now been modernized to keep tabs on television. And through some special characteristic of the new medium, it is possible to read, from the pressure chart, not only the popularity of the show, but the time and torment of each commercial. Recent news stories from St. Louis, Boston, Chicago, Hartford, Toledo, and New York all feature the fact that the finish of popular programs as well as the time-outs for commercials make people so thirsty "or something" that the pressure gages at the water departments take a big dip.

Particularly popular with video viewers have been the "fights." Thus, at Toledo and Hartford in January, Gavilan's knockout of Davey threatened to knock out the water system as well, with sudden jumps in demand that measured 32 per cent and 1 mil gal, respectively. Chicagoans, meanwhile, failed to get more than 11 psi excited about the Gavilanche, compared to their 18-psi response to the Louis-Charles fight of 1950. About the only unpugilistic program that has even begun to measure up to boxing in its water rating is the "I Love Lucy" show, on which Lucy's recent 8-lb baby actually weighed in at a 12½-lb pressure drop in Chicago pumping stations.

Primary problem now, before water utilities can apply this new type of service to the task of increasing their earning capacity, is the development of some standard system of measurement to replace the welter of percentages, gallonages, and pressures now being used. George Van Dorp, Toledo's commissioner of water, has already made a start on this with a point system that converted the Davey knockout count from 32 per cent to 169.6 points. Certainly this is precise enough to sound accurate enough to use, but we doubt that even Toledo's

(*Continued on page 34 P&R*)

(Continued from page 33 P&R)

reputation for good scales will sell the system sight unseen.

Meanwhile, we are working on a system of our own based on the fundamental observation:

$$P_{wfs} \propto \frac{1}{S_i(S_l - C_l)}$$

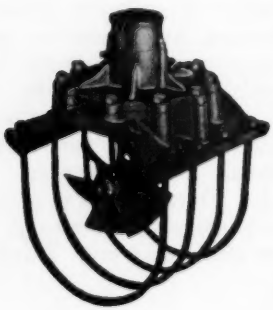
in which P_{wfs} is the water pressure following the show; S_i, the interest in the show; S_l, the length of the show; and C_l, the length of the commercial. To make the system comprehensive, of course, we must also take into account the qualitative relationship of the commercial, expressed as:

$$P_w \propto \frac{1}{P_s}$$

in which P_w is water pressure and P_s is salesmanship pressure. Right now we are working on a factor which will take into account such basic variations as the average age of the local population, the normal pressure on the water system, the number of television outlets available, the amount of storage on the system, not to mention the proportion of flushometer to tank-type toilet fixtures. As a matter of fact, we're working night and day to come up with a satisfactory system before the sewage works folks start metering their lines to get at the gravy from the other direction. And, of course, we expect to wait until the P&Rating system is accepted throughout the field before we relinquish our now unassailable objectivity by buying a TV set of our own.

Belle and spigot pipe is what they had out in Arcadia, Calif., last month, when 4-year-old Heather McLaughlin stepped into a 10-in. diameter vertical section of pipe that was uncovered. Fortunately Heather weathered a 2-hour imprisonment in high spirits, despite the fact that rescuers had to dig and saw all around her before they could release her shoes from the valve in which they had been wedged. The moral: cap it, or kaput!

(Continued on page 36 P&R)



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(Continued from page 34 P&R)

Journal readers who are being crowded out of home or office by constantly swelling accumulations of technical literature, and are therefore in a give-away temper, are hereby notified of an appeal that is being conducted on behalf of libraries and schools in Israel. Good-deed your surplus to Books for Israel, 115 King St., New York 14, N.Y.

The iron horse has turned out to be a gift horse, and more than that a gift horse into whose mouth you'll be able to look any day now. Which is to say that the Santa Fe Railroad just presented a complete water system to the city of Winslow, Ariz., and the city is preparing to introduce fluoridation upon taking over the supply.

The medical schools of the nation —all 79 of them—will obtain some much-needed relief from a fund that American industry is trying to raise for them. And it is fitting that the water works industry should help secure the shrinking supply of doctors. For years now it has been apparent that the purification engineer's victory over typhoid fever and other waterborne ailments has not resulted in technological unemployment for the medics, nor even in increased leisure time. On the contrary, it appears that people are bypassing the oldfashioned killers merely to face those degenerative and chronic ailments of later life which are working the family doctor to death and creating a real doctor shortage. Send your aid to the National Fund for Medical Education, 2 W. 46th St., New York 36, N.Y.; and if you can't make a sanitary engineer out of your son, try making him a doctor. We haven't heard from the dentists yet, but this throws a new light on fluoridation.

(Continued on page 38 P&R)

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That's right, it isn't any ordinary bubble. Welsbach Ozone is an extremely potent and effective bubble when it is used to destroy taste and odor in your city's water.
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(Continued from page 36 P&R)

The ASPCF, an organization we recently founded, not to frustrate fishermen, but to guarantee them freedom of their kind of religion through cooperation in the fight against stream pollution, recently took note of the fact that approximately 1,000 tons of copper, worth half a million dollars, and similar amounts of zinc, are carried down the Naugatuck River annually as acid wastes from the Connecticut brass industry. Since the river's banks pay no dividends on these deposits, it is thought that the brass companies ought to be more than willing to decupricate and dezincify the piscatorial environment involved. "A dog's life" it used to be, until the ASPCA practically canonized caninity. "A fish's life" it's been ever since, so join the ASPCF now and "Save the Pisces!"

Not just fish, but fowl, too, require lots of water these days. And, according to a recent survey at Michigan State College, the installation of running water—i.e., modern conveniences, in hen coop parlance—will considerably increase egg production. All of which ought to prove that, though chickens can be fooled by such poultrymen's tricks as night lighting, when it comes to the really essential things, they know what they are doing. And speaking of chicks who know what they're doing reminds us to report that Mary Martin used approximately 3,000 gal of water in washing her hair on the stage during 1,500 performances of *South Pacific.*

The Chicago water and sewer systems, formerly included under the jurisdiction of the Dept. of Public Works, have been reorganized under a separate Dept. of Water & Sewers, which in turn is subdivided into two bureaus. James W. Jardine has been named commissioner of the new department and W. W. DeBerard, city engineer, is now known as deputy commissioner for water and chief water engineer. H. H. Gerstein, formerly chief filtration chemist, has been appointed chief water engineer to assist DeBerard. Gerstein has been succeeded as chief filtration chemist by Oscar Gullans, previously the director of the filtration laboratories. Gullans in turn has been succeeded by James Vaughn, filtration engineer. One final change is the appointment of Nicholas Kuehn as chief sanitary engineer in charge of the Water Safety Control Div. of John R. Baylis' Water Purification Div.

Aqua Anonymous is the name of a new organization recently established at Houston, Tex., apparently to intercept candidates for the better known Alcoholics Anonymous. As described in the Houston *Post* last month, the members, "using familiar glasses only, put in the usual number of ice cubes, the usual amount of water, leaving only the bourbon out. Theoretically, you hardly notice its absence. The drink looks the same (always put a paper napkin around the glass), the drink sounds the same, and you're almost convinced." Actually, we're more than a little surprised that so drought-stricken a community as Houston would tolerate such a group, and, much as we are pleased with the implied compliment to water, we can't quite forgive the determination to keep it anonymous. Anyway, Aquatics Anonymous would have been more euphonious—or should that be just phonyous?

(Continued on page 40 P&R)

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Armco Welded Steel Pipe comes in lengths up to 50 feet. This means that you could install a mile of this pipe with only 106 joints. And because of these long lengths you have fewer pipe sections to haul and handle, which also helps to cut down installation costs.

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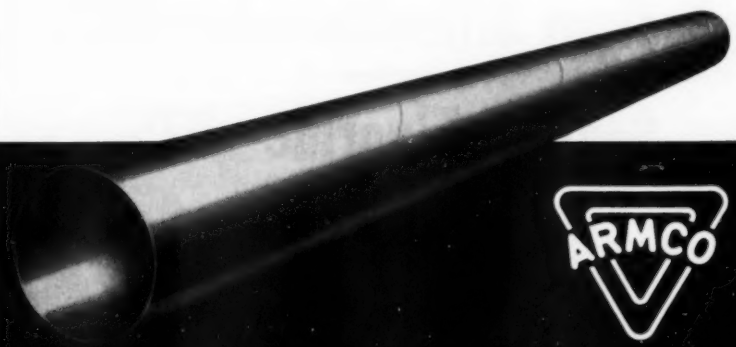

ARMCO

ARMCO WELDED STEEL PIPE

Meets A.W.W.A. Steel Water Pipe Specifications

(Continued from page 38 P&R)

Water supply medication again—only this time as a credit rather than a charge, although the two public water supplies involved are consumed by a couple million people. First therapeutic thirstquenchant is that supplied to Boston, Mass., for which a native, seriously ill in Watervliet, N.Y., put in an emergency call just last month. What's more American Airlines arranged a gallon-jug waterlift which it has promised to maintain until the woman is restored to health—at least! The other pipeborne panacea is that provided by the Gary-Hobart Water Corp., which was invoked by Prophet Jones, Detroit spiritual leader, and imbibed by a dying Mrs. Esther Jackson of Gary. Having made an appointment with Prophet Jones, Mrs. Jackson was instructed to make four trips to the Gary bus station to drink from its water fountain before the consultation. That was in 1949, and Mrs. Jackson is alive and well today at 70—presumably an habitue of Gary's Greyhound depot. But what brought the story out at this late date was the gift of a $12,900 white mink coat to the ruler of the Church of the Universal Triumph by Mrs. Jackson's two daughters, in gratitude for his saving their mother. Forgotten man, as usual, was the manager of the water utility, Harold Rudgal, who ought to have rated at least a mink stole for his part in the cure. Ah well! He probably wouldn't wear it anyway—even to prove that water really *is* the best medicine.

(Continued on page 42 P&R)

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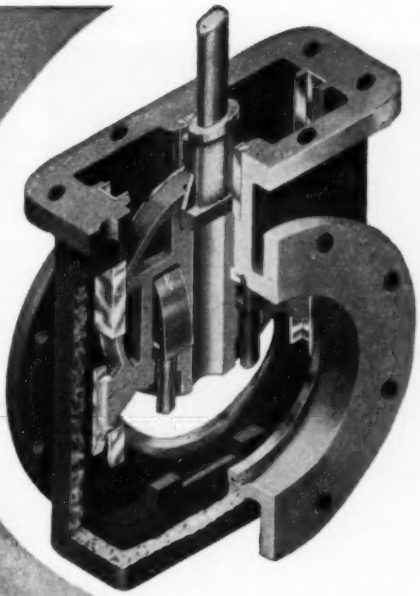

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When valve is opened, each of the three shoes on both discs immediately contact the feathered edge of the tracks. These three contacts result in the disc being eased away instantly from the seat. The shoes then ride the tracks squarely and firmly for the full travel of the disc. In closing, discs ride the tracks down to a point exactly opposite the valve seat. At that point, the discs are clear and free to seat by action of the two spreaders, each functioning independently of the other.

M & H double square bottom valve prevents the down stream gate from tilting into the down stream port opening and by chatter or vibration damaging the seat and gate rings. These valves can be installed with either disc on the down stream side.

Available in classes A, B, and C, sizes 3″ and larger. Where needed, can be supplied with rollers; or roller, tracks and scrapers. For complete information, write or wire M & H Valve and Fittings Company, Anniston, Alabama.

M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION

(*Continued from page 40 P&R*)

Half a century of service to his company and the industries it serves are signalized by the presentation to Charles G. Richardson, vice-president of Builders-Providence, Inc., of a watch and billfold. Making the presentation at the annual service award dinner of the firm is Henry S. Chafee, company treasurer.

Taste is getting our gals into hot water these days. "U.S. women," says a famous tea taster, "don't know how to boil water"—a pretty serious charge to us who consider that art our last line of defense against impurity when anything goes wrong at the water works. Not just water either, but other things brides cook these days apparently need to be blushed about—particularly now that spectrophotometric methods permit the groom to prove his traditional complaint that "it doesn't taste like mother's cooking." Were we one of the water works wives, though, we'd be sure to recall the wonderful taste of that well water back home—from the well beside the outhouse.

Not just the taste, but the color of really raw water can make a pretty potent argument when properly put. Thus, out at Cedar Rapids, Iowa, where a colored oleo fight is in progress, a newspaper columnist neatly turned the argument of one of the opposition into water supply terms. "Save the town, restore the brown," cried Richard Pinney of the Cedar Rapids *Tribune,* claiming that the city's drinking water was "a shame, a colossal hoax perpetrated on an innocent public." Pointing out that the clean, clear water coming out of the taps is not at all the well or spring supply it appears to be, but Cedar River water, "the color of hot chocolate and the consistency of cold sorghum," Pinney wants it to appear under its true colors. Furthermore, says he, "there ought to be a big tax of some sort on the city supply so that its price isn't so out of line with the bottled spring waters." Water down his opponent's argument Richard certainly did, and think of how he buttered us up. OLeo Louis, incidentally, is Cedar Rapids new name for its water supertendent.

S. Logan Kerr, consulting engineer of Flourtown, Pa., has been made a Fellow and Life Member of the American Society of Mechanical Engineers. Kerr is widely known as an expert hydraulic engineer, particularly in the fields of water power, water supply, pumping, and water hammer and surge control.

Luther T. Fawcett, chief engineer of the Mahoning Valley Sanitary Dist., received a citation from the Ohio Society of Professional Engineers for "outstanding engineering contributions to the public welfare."

(*Continued on page 44 P&R*)

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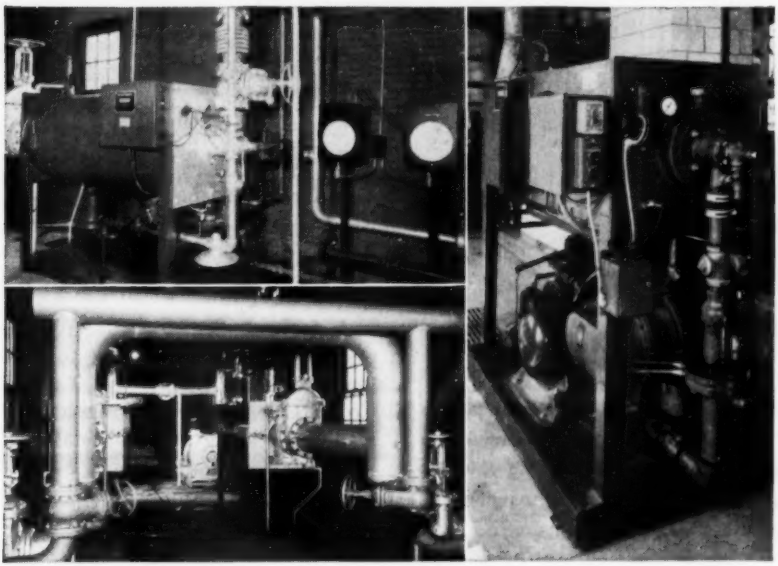

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Please send me a copy of "Alum—Commercial Aluminum Sulfate."
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In Canada: North American Cyanamid Limited, Toronto and Montreal

(Continued from page 42 P&R)

A main drilling machine for use on cast-iron, steel, or asbestos-cement mains is being offered by Hays Mfg. Co. of Erie, Pa. As shown above, the machine is being used to install a Hays Duo-Stop, combined corporation stop and saddle, on a main under pressure. The operation is the same when corporation stop and saddle are separate.

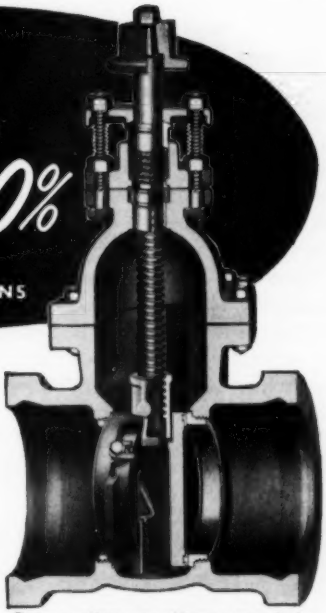
Archaeologists have finally found a real missing link in some diggings at Yorkshire, England. The reason they haven't become more excited with their luck is the fact that the link was an ordinary iron one, unearthed with a lot of nails and other iron implements. What makes the link so real, though, is its remarkable state of preservation after 2,000 years in the ground, and the almost obvious connection with the tannic acid that oozed from old leather cuttings which had been buried next to the metal. How long now till tannic acid coatings for corrosion prevention to replace those obsolete wrapping techniques picked up from the mummy lore of the same archaeologists?

(Continued on page 46 P&R)

FOR YOUR PROTECTION...

Crane Valves Comply 100%

WITH CURRENT A.W.W.A. SPECIFICATIONS



Cross-section non-rising stem, hub ends. As made in sizes 12-inch and smaller.

If you want an A.W.W.A. valve that's actually built to give better service—don't settle for less than Crane. For Crane valves meet or exceed *every* requirement of current A.W.W.A. specifications. These include—

- Unobstructed waterway.
- Minimum body metal.
- Semi-finished nuts that are rustproof.
- Minimum stem root diameters.
- Full compliance with hydrostatic shell and seat tests.

Furthermore, Crane gives you added refinements like these:

- In Crane valves, all sizes have stuffing box and bonnet bushings—reducing torque required for operation.
- Greater number of bonnet bolts to provide more uniform gasket loading, thus minimizing the possibility of leakage.
- Equipped with bonnet bolt studs in place of square head bolts.
- All sizes bear complete identification to facilitate ordering of parts.

Yes, Crane builds the best A.W.W.A. valve you can buy—a valve that's good for a long service life with a minimum of maintenance and repair. Ask for folder AD 1778, or see your Crane Representative.

Your choice of 3 Patterns

Non-rising stem with operating nut, hub ends, as above, 2 to 36 in.

Non-rising stem with hand wheel, flanged ends, 2 to 24 in.

Outside screw and yoke with hand wheel, flanged ends, 2 to 24 in.

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Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

(Continued from page 44 P&R)

"Go wet, young man" is the new form of an old exhortation. Go wet, in fact, to see the world—and quickly, too, if last month's travels of the P&R clippers are any indication. Texas, Spain, Jerusalem, Kuwait, Kenya, and back to Illinois—all points wet in their worries.

Texas and Spain have in common a relatively newly deadly drydom—25 consecutive rainless days in Spain having seriously threatened the cereal crops which are the nation's food supply, and two consecutive years of rainlessness having given water the choice over oil as the most precious liquid of the Lone Star State. As a matter of fact, water conservation measures in Texas are said to have reached the point where postage stamps are being paper-clipped to letters and it is a fact that the city of Houston is considering sinking a half-million more dollars into the ground in the form of five additional wells.

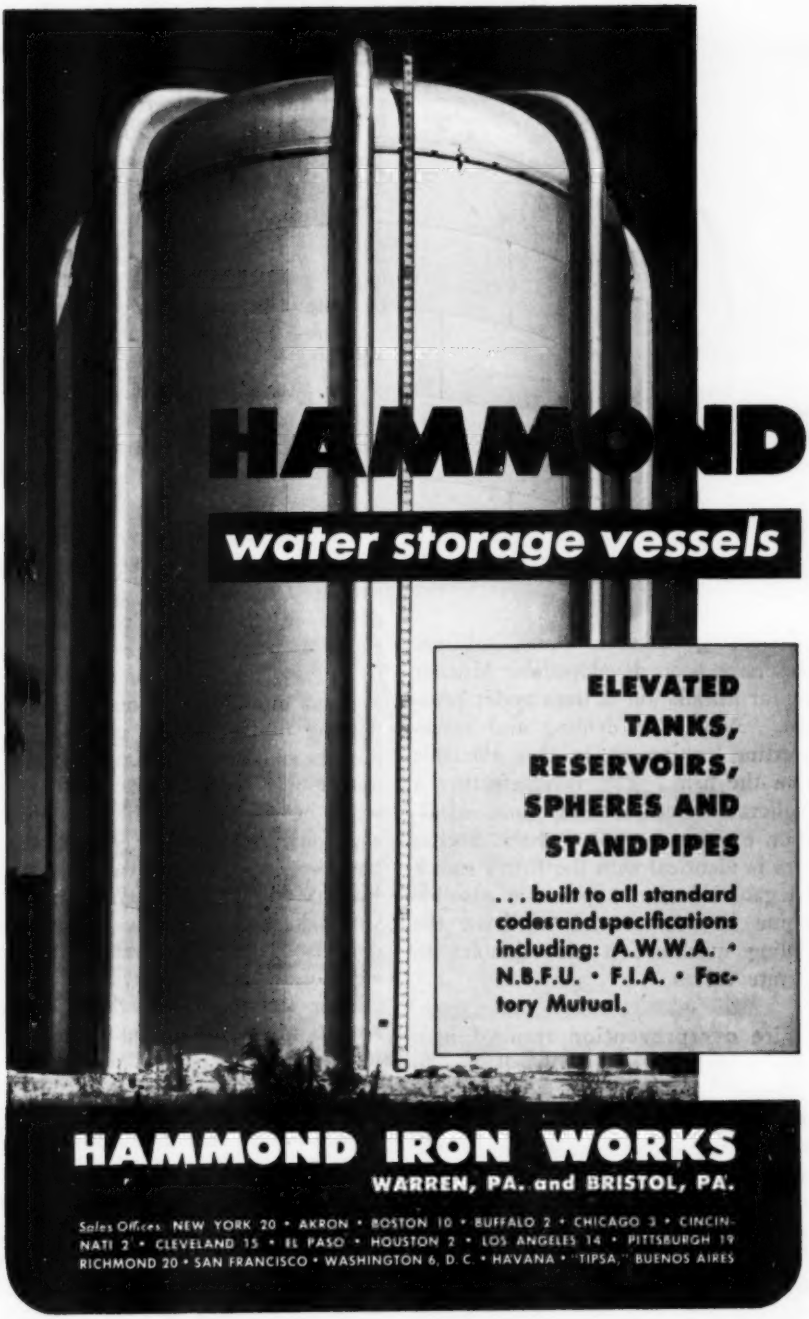
In Jerusalem and Kuwait, the problem is basically the same, but more so. The thirst which has plagued Jerusalem since pre-Biblical times is now to be cured by a pipeline across 12½ mi of rocks and craggy slopes to wells near Tel Aviv, but all of Israel wants water badly, for irrigation, industrial development, comfort, and health. And in oil-rich Kuwait on the Persian Gulf, booming now with trade and progress, it is a 1.2-mgd sea-water distillation plant for public supply that provides the real boom juice.

The story from Kenya, on the other hand, is of primitiveness rather than civilization—of the country's northern frontier, where the natives are mainly nomadic cattle drovers whose entire lives are "a pilgrimage to water." Water there is to be had for the taking, but the taking is complicated, not only by the quantity but the quality of takers, including, as they do, lions, leopards, and sundry other blood- as well as water-thirsters. And back in Illinois, the taking ain't always easy either, even on the uncompetitive acres of a Putnam County farm. There it was, last month that one "Never Say Dry" Hartman had to go to a depth of 1,700 ft and $20,000 to strike a supply.

What price water, indeed, and, with plain paleontological proof that the northern hemisphere is slowly getting warmer and drier staring us in the face, what even higher price for water soon? It is Professor Paul B. Sears of Yale Univ. who, through a study of fossilized pollen dug up in Mexico and New Mexico, has been able to demonstrate a cycle of cold and wet to hot and dry that indicates a current trend toward sunshine and water scarcity scheduled to last for several centuries. Just how soon seer Sears' searing will start isn't said, but we can hope that the mere threat of it may establish that deeper appreciation and higher price that our water supplies so urgently require. Who knows but what the young man who makes up his mind to go wet professionally may also be assured that he can go eat.

Marion C. Welch has joined the firm of municipal engineering consultants of Miles O. Sherrill, Louisville, Ky. The first is at present engaged in a number of municipal engineering projects, including the location, design, and construction of four municipal swimming pools for Huntington, W.Va.— a project which, because of a civil-rights ruling banning segregation, has aroused much interest.

(Continued on page 48 P&R)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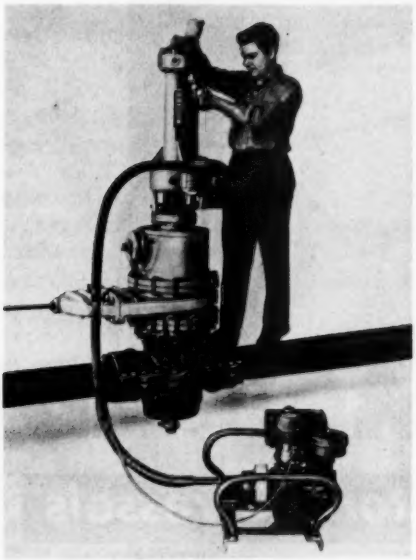
(*Continued from page 46 P&R*)



Inserting valves in 4-, 6-, and 8-in. sizes have been developed by Mueller Co. for installation in lines under pressure. Associated drilling and valve-inserting equipment is also available from the firm. The valves feature a smaller sleeve size to facilitate installation in limited space, but the mechanism is identical with the firm's standard gate valves. A portable gasoline engine is also offered to drive the drilling machine; it also doubles to operate valves.

Fire overprevention resulted in a lot of cold dinners along Brasil Ave. in Tiajuana, Mexico, last month when some apparently overzealous contra-arsonist connected a water line to the gas pipe, creating four fountains in every kitchen along the avenue. It took ten days for the gas company to discover the source of the difficulty and to get its customers back to cooking with gas—ten days during which the company manager did what burning was done, getting hot enough to call in the district attorney. Of course, if the gas stove were to begin splashing instead of searing our steak, even we might be ready to admit that it was perhaps a little too much of a good thing.

A new chlorine dispenser has been produced by Fischer & Porter Co. of Hatboro, Pa. with a maximum capacity of 1,000 lb per day. The mechanism is a vacuum type utilizing solution feed, and may be controlled manually or by automatic proportioning.

Lincoln's birthday, just past, brought out the fact that Abe, too, appreciated good drinking water and didn't hesitate to recommend the especially palatable supplies of Tennessee to quench the thirst of a 70-year-old accused murderess whom he was defending in the Illinois courts. Actually the old lady had bopped her bibulous spouse with a piece of stovewood when he was choking her for opening a window, but it appeared that nobody but the court considered it murder. History doesn't report whether Melissa Govings, the self-made widow, ever did taste Tennessee water, but some eight years after her trial was called off for lack of a defendant, she was known to be out in California, where it is rumored she had an interest in some scheme to distill sea water to provide for her thirsty new state.

R. C. Bardwell, longtime superintendent of the Cheaspeake & Ohio Ry. water supply, has retired after approximately 30 years of service to the line. He received the Fuller Award from the Virginia Section in 1944.

Portland, Ore., contractor reports:

Chas. T. Parker, of Parker-Schram Co., says: "On this 36" pipe line using Dresser Couplings, a foreman, crane operator, oiler and six-man crew were able to average 15 lengths per day, complete except for coating. This in spite of almost incessant heavy rains. Where ditch was available without obstruction, we were able to complete about five lengths per hour. We know of no better method of connecting lengths of pipe in a water line."

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The cheapest way to deliver water to the place where it turns into revenue is with a Dresser-Coupled steel line—the line that cuts *installation* costs, *leakage* losses and *maintenance* costs.

As in the case of this Portland water main, construction of a Dresser-Coupled line keeps going despite adverse weather conditions. Because a wrench is the only tool needed to make joints, costly weather delays are minimized or eliminated. And, in good weather, this type of construction sets a pace no other method can equal. The line starts paying its way sooner.

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Correspondence

Manila Buildup

The following excerpts are taken from a letter from AWWA member Manuel Mañosa, general manager of the Metropolitan Water Dist. at Manila, P.I., to Lloyd K. Clark, of Clark & Groff Engineers, Salem, Ore. Clark is the author of a paper, "Restoring Manila's Water System to Service" which was based on his wartime experiences. It was published in the May 1946 JOURNAL *AWWA, Vol. 38, p. 608.*

We have done a great deal of reconstruction work which has gone far in improving water and sewer services, the reservation, and other installations of the District. For the year 1952, we have accomplished the following projects:

Construction of 25,946 m of new water mains ranging in sizes from 2 to 12 in. diameter, at an approximate cost of 866,500 pesos.

Construction of 10,000 m of new sewer mains ranging in sizes from 8 to 18 in. diameter at an approximate cost of 350,000 pesos.

In line with the social justice program of the administration, we have constructed several employees' quarters and remodeled many others at Balara, Novaliches, Bicti, Ipo, and El Deposito at an approximate cost of 150,000 pesos.

We have also constructed recreation facilities and continual sanitary improvement at Balara, Novaliches, Metropolitan Water Dist. area.

Presently, we are importing 6,100 m of 48-in. steel pipe and fittings from the Bethlehem Steel Export Corp., New York, N. Y. The first shipment is expected to arrive about the middle of next month. These steel pipes and fittings will be used for the construction of 6.10 km aqueduct 48 in. in diameter along the España Extension, which will ultimately cost 3,300,000 pesos. This project, when completed, will relieve the low pressure now prevailing on the north side of Manila and northern suburbs.

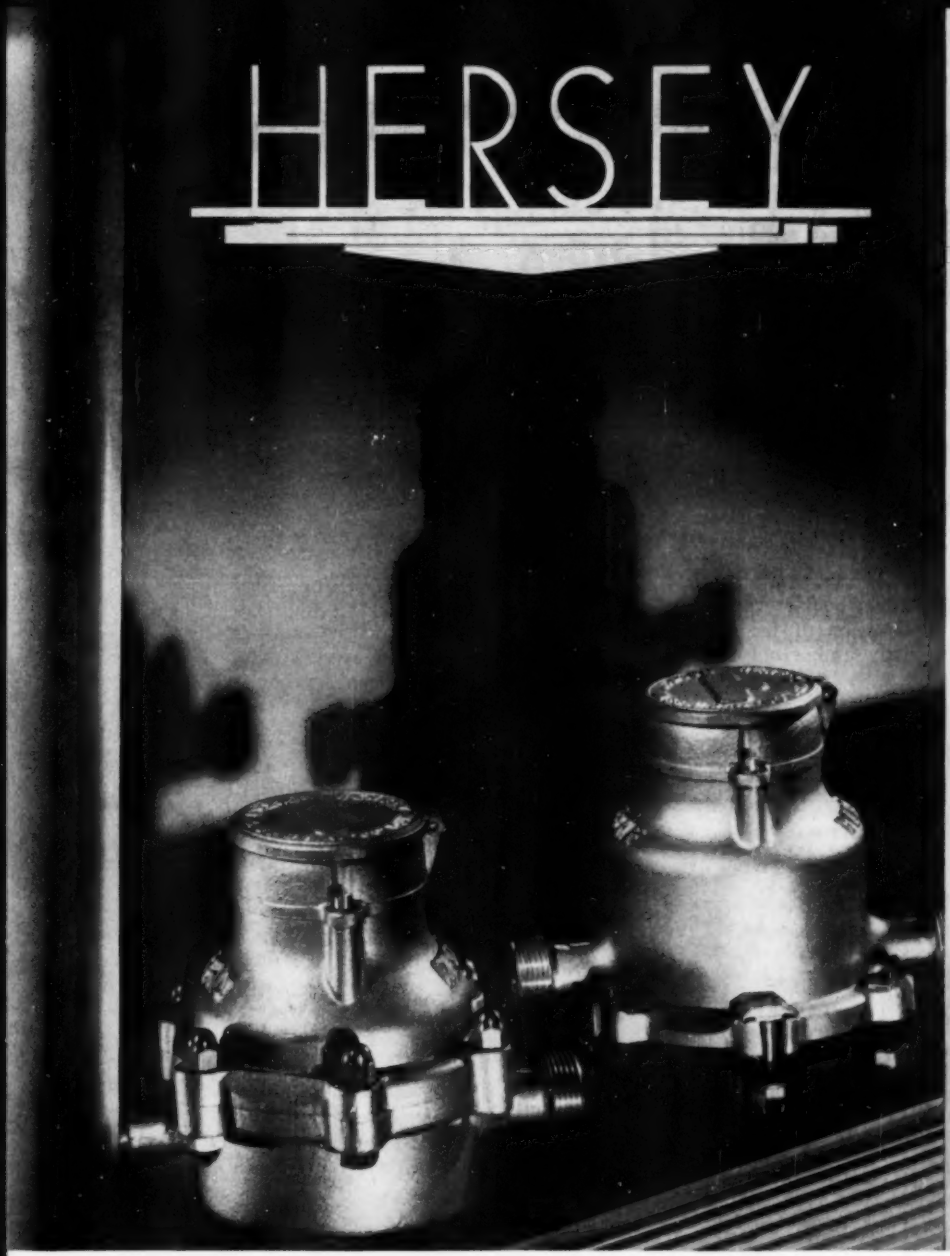
For the relief of the water shortage in Malate, Pasay, Parañaque, and Las Piñas, a 16-in. asbestos-cement water main, 8,250 m long from Santa Ana to Paranaque Tank, has just been started. This project will cost about 1,245,000 pesos when completed.

We have many more proposed projects to keep us with the water and sewer service demands of the recently developed areas. The development of these projects is, however, limited to the income of the District and the limits of our borrowing capacity. Our average consumption is now 87 mgd.

We also have a booth in the International Fair Grounds which, in the opinion of others, is above the average in beauty, display of exhibits, and comfort. . . .

By the way, now that we are again in the fringe of another presidential election, you may be interested in learning that Defense Secretary Magsaysay [since resigned] is the nephew of the former manager of the Metropolitan Water Dist.

MANUEL MAÑOSA
Gen. Mgr.
Metropolitan Water Dist.
Manila, P.I.; Feb. 12, 1953



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The Reading Meter

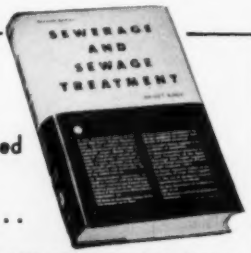
Demineralization of Saline Waters. *Bureau of Reclamation, Geological Survey, and Bureau of Mines; U.S. Dept. of the Interior; Washington, D.C. (1952) 66 pp.; paperbound; free from the Office of Saline Water Research Coordination, Dept. of the Interior, Washington 25, D.C.*

This booklet represents a preliminary discussion of the research program recently authorized by the Congress, and includes an outline and description of potential processes plus an annotated bibliography. Purpose of the outline is the stimulation of interest in the program and the evocation of suggestions and comments from interested parties. Among potential separation processes listed are such physical processes as various vaporization methods, crystallization, and diffusion; chemical processes include ion exchange, hydration, and precipitation. Electrical methods constitute a third major classification and include, among other methods, that of electro-ion-migration. Various energy sources are also listed for consideration.

A Survey of the Literature of Dental Caries. *Guttorm Toverud, Gerald J. Cox, Sidney B. Finn, Charles F. Bodecker, & James H. Shaw. Pub. 225, National Academy of Sciences–National Research Council, 2101 Constitution Ave., Washington 7, D.C. (1952) 567 pp.; $3*

This book represents a monumental and, to the dentist, doubtless an invaluable work of scholarship. To the policy-making water works executive, the 90-page section on "Fluorine and Dental Caries" is alone worth the purchase price. Here, succinctly and searchingly summarized, are the basic facts that everyone concerned with the possibility, the evaluation, or the justification of water fluoridation should have at hand. Clinical studies of the effects of fluoride-bearing waters upon those who have been drinking such waters all their lives, and the various levels of fluoride in water which are associated with undesirable mottling of teeth and toxic systemic effects are discussed. The opposition to fluoridation is examined carefully, and dismissed with the comment that:

(*Continued on page 54 P&R*)



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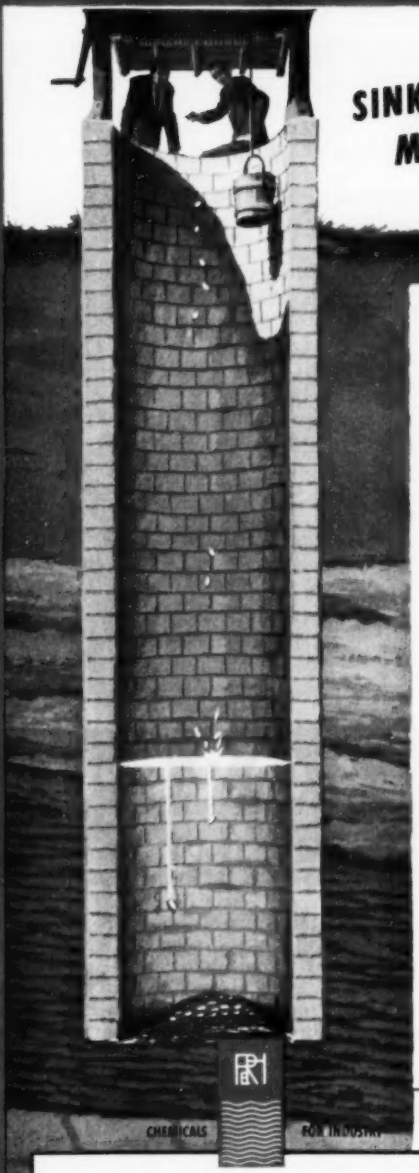

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The Reading Meter

(*Continued from page 52 P&R*)

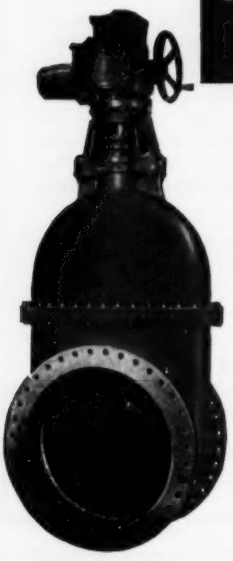
Opponents of the proposal to fluoridize water for the partial prevention of dental caries have generally been motivated by a fear of toxic consequences rather than by doubts of effectiveness. In many cases casual remarks have been made against the procedure that indicate the authors have not examined the proposals in their entirety. . . . No one has yet proposed the production of mottled enamel to prevent dental caries. . . .

One unavoidable defect in so exhaustive a compilation as this book represents is that it is of necessity dated; none of the striking studies published after July 1950 could be included. It is doubtful, however, whether the optimistic reports since received of the Newburgh-Kingston study, for example, would change the authors' basic conclusion:

If there is a common water supply, the simplest, safest, and most effective way to provide the extra requirement of fluorine is through the addition of fluorides to the water in amounts adjusted to the climatic and seasonal needs.

Water-Loss Investigations: Vol. 1—Lake Hefner Studies. *Technical Report. Circular 229, Geological Survey, Washington 25, D.C. (1952) 153 pp.; paperbound; free*

This technical report of procedures and results is hardly general reading, but it will interest those who wanted more data than were contained in the study by G. Earl Harbeck Jr. in the August 1952 JOURNAL: "Evaporation Research at Lake Hefner." The Weather Bureau and the Navy's Bureau of Ships and Electronics Laboratory collaborated with the Geological Survey in preparing the report.



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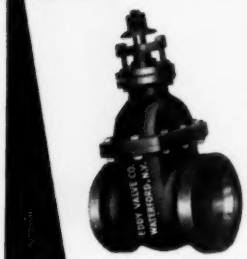

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CORROSION AND CORROSION CONTROL

Performance of Magnesium Galvanic Anodes in Underground Service. OLIVER OSBORN & H. A. ROBINSON. Corrosion, **8**: 114 (Apr. '52). Performance of magnesium galvanic anodes in underground service reviewed in light of past 5 yr of field testing in which more than 2,500 anodes have been tested in 40 different backfills and in various soils. Pertinent indices of galvanic-anode performance cited and various factors influencing performance of magnesium anodes enumerated. Summary of most outstanding findings on anode current eff., anode current output and stability of current flow presented. Effects of such factors as anode compn. and impurities, current density, time, backfill compn., installation practice, soil characteristics, and weather on anode performance discussed. High-purity Mg-6Al-3Zn alloy continues to provide most consistently efficient performance. At current flows equiv. to 10-yr life, effs. corresponding to 500 amp-hr/lb are usually realized, except in high-chloride soils where higher current densities are needed to get comparable effs. Impurities, notably nickel, iron, and copper, must be held at low concn. levels in order to realize good anode eff. Pure commercial (cell) magnesium anodes occasionally exhibit high effs., but statistical experience shows their performance to be decidedly inferior to that of high-purity alloy. Field tests show eff. of alloy anodes increases with current density as previously indicated by lab. data. Likewise, eff. tends to increase with time, for periods up to at least 2 yr. With exception of magnesium sulfite and chromic acid backfills, compn. of backfills used appears to have no very signif. effect on anode eff. Anode current output essentially function of soil resistivity and cathode potential, although influenced to some extent by backfill compn. and backfill installation practice. Statistical data indicate that backfills installed dry provide higher level of current output than is obtained with wet (mud) backfills. Likewise, high-cond. backfills appear to provide significantly higher current flow. Excellent maint. of current flow observed for periods of 3–5 yr on relatively large numbers of anodes. Most stable current flows associated with deep installations and poor-to-fair soil drainage. Well-drained installations on slopes or elevations tend to exhibit poor current maint. Depletion of sol. backfill ingredients (gypsum, sodium sulfate) evident after 3–4-yr service, but current flow not adversely affected so long as moisture supply adequate. Bentonite-rich backfills are highly moisture sensitive and tend to expand or shrink excessively with fluctuating moisture levels. If installed wet, they sometimes shrink enough to affect adversely anode-to-earth resistance. Stability of current flow also affected by rainfall and temp., temp. effect being most pronounced where winters coldest. Current flows usually well maintd. until anode 85–95% exhausted.—*Corr.*

Vigilance Underground. A Summary of Progress on Preventing Electrochemical Corrosion on Buried Pipelines. BRYAN PATTERSON. Corrosion, **8**:241 ('52). Need for control of corrosion in underground metal explained, and elements of planning electrochem. control outlined. Principles of weighing dielectric control with economics given, and limitations and sequence of recommended dielectric tests listed. Survey of common specifications and inspection fundamentals followed by recommendations concerning electronic inspection after lines are in service.—*Corr.*

Microbiological Corrosion of Buried Steel Pipe. F. E. KULMAN. Corrosion, **9**:11 ('53). Early corrosion investigations in New York City concerned with electrolysis

(*Continued on page 64*)

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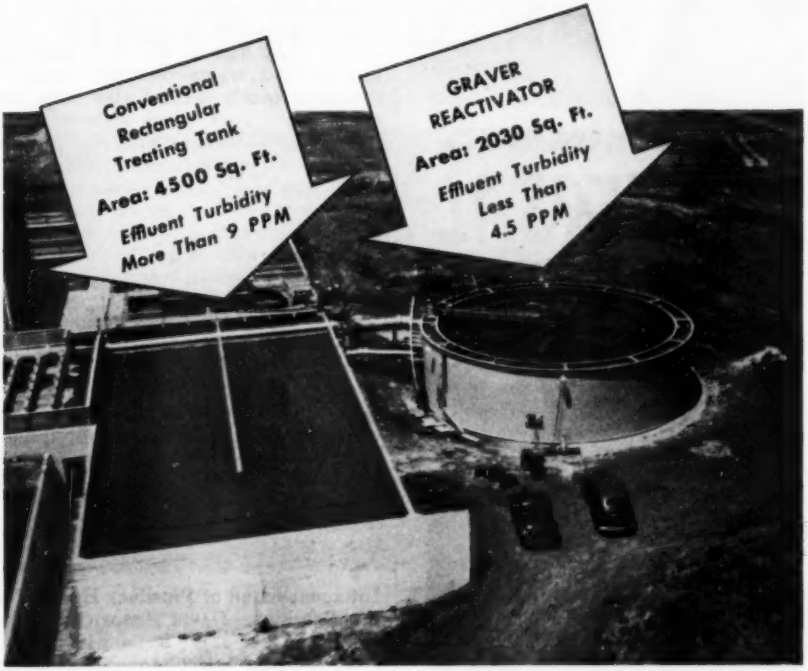

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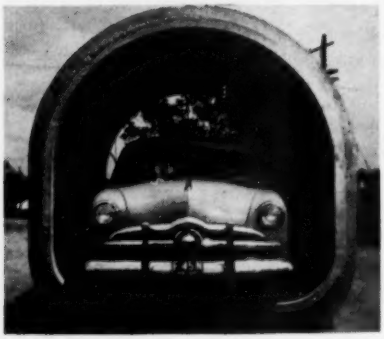

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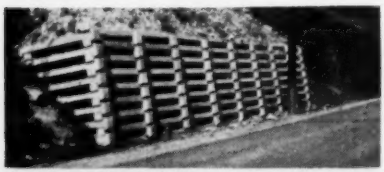

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(Continued from page 62)

caused by stray currents leaking from elevated and trolley lines. Problem solved by installing insulating joints in gas mains. Attention then given to mitigating soil corrosion responsible for many leaks experienced. Test data at 472 field excavations showed most severe corrosion usually occurred in poorly aerated clay soils contg. org. matter. Bact. action indicated in 81% of locations of severe corrosion. This revelation prompted detailed investigation of bact. influence in underground corrosion. Pop. counts of 5 types of anaerobic and aerobic bacteria detd. at corrosive locations, concurrently with measurements of moisture content, org. matter, aeration and pH of soil, and presence of sulfide in corrosion product. Seasonal variations in soil moisture, aeration, and pop. of anaerobic bacteria found to be associated with underground corrosion cycle. Following discussion on probable mechanisms of bact. corrosion, need for further improvement of soil redox probe developed in Am. Gas Assn. investigation is indicated. This probe measures reducing intensity of soil and thus locates corrosion areas prior to installing pipe.

Interconnection of Pipelines Having Various Coatings. David Hendrickson. Corrosion, **8**:212 ('52). Deals with design of concrete-coated steel aqueducts interconnected with aqueducts with bituminous coating. Galvanic current generated by interconnecting 2 aqueducts with different coatings shown in specific case. Proper method for isolating these aqueducts discussed, as well as results of trying to isolate 2 pipelines by installing insulating joints within network of interconnecting pipes. Test data given on forced drainage of these incorrectly placed insulating joints in order to reverse residual galvanic currents in pipe network. Reason operating experience should not overrule recommendations based on electrolysis investigation given. Method developed for locating accidental short circuits in control piping, conduits, and other metallic connections given. Comparison based on soil resistivity made between Mokelumne aqueducts and Hetch Hetchy aqueducts for galvanic currents generated by interconnection. Precautions in form of soil survey were taken by Hetch Hetchy engineers. Insulating joints were installed in their first

(Continued on page 66)

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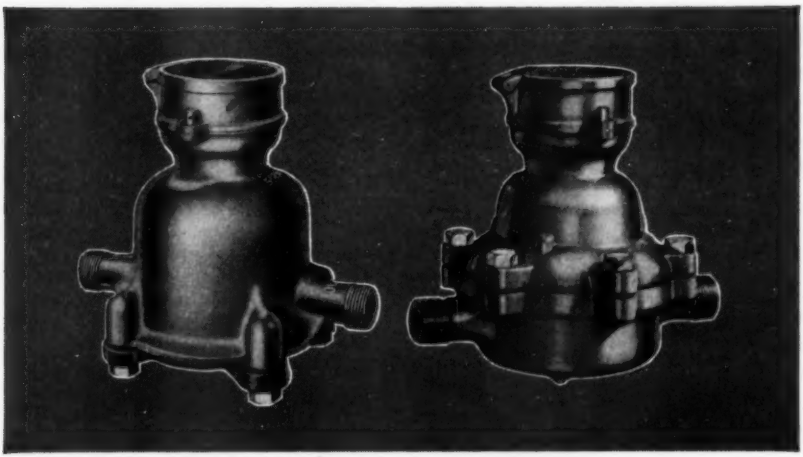

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(*Continued from page 64*)

aqueduct at strategic points. Test data given on these insulated joints after 17 yr of service. Good results obtained by following recommendations based on electrolysis surveys for pipe coatings. Accidental short circuit between 2 Hetch Hetchy aqueducts at San Joaquin valve house discovered by prelim. electrolysis survey after installation of second aqueduct. Misconception of some engineers that welding machine grounded to one aqueduct may be used just as effectively on adjacent aqueduct without ill effect has resulted in much disregard for recommendations made by electrolysis engineer. Recommended precautions set forth in conclusion of paper.—*Corr.*

Soil Resistivity Measurements for Corrosion Control. F. O. WATERS. Corrosion, **8**:407 ('52). Results of expts. to det. most practical soil survey procedure and best equip. given. Correlation between soil resistivity and corrosion divided into 5 classes. Soil corrosivity maps of area served by Southern Calif. Gas Co. prepd. Details of several types of equip. for detg. soil resistivity given with good and bad points of each. Rules for interpretation of results listed, and use of soil resistivity detns. in selecting types of coating outlined.—*Corr.*

The Role of Oxygen in Corrosion and Cathodic Protection. R. V. COMEAUX. Corrosion, **8**:305 ('52). Oxidation of iron accompanied by simultaneous reduction of some other material. In buried steel, above pH 4.5, reduced substance is oxygen. 2 electrons furnished by corrosion of iron atom reduce half molecule of oxygen to hydroxyl ion. Corrosion ceases if access of oxygen to all points of surface elimd. Complete cathodic protection achieved when electrons are supplied at steel surface at same rate oxygen molecules diffuse to surface. Current drainage of 1 ma/sq ft equiv. to 6.24×10^{15} electrons/sq ft/sec; this amt. reduces 1.56×10^{15} molecules of oxygen, or amt. of oxygen in 318 monolayers of water.

(*Continued on page 68*)

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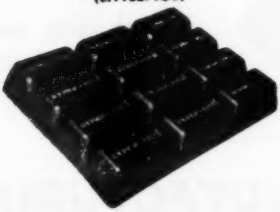

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(Continued from page 66)

This establishes role of diffusion of oxygen in cathodic protection; any factor which affects diffusion of oxygen to steel surface will affect current requirements for cathodic protection. Baytown Refinery cathodic protection system drains 12,000 amp, amt. just sufficient to reduce 1 g of oxygen per second reaching buried surface area of approx. 10 mil sq ft. Roughly estd. that avg thickness of soil diffusion layer in Baytown Refinery equiv. to 1 in. of quiescent water. Influence of thickness of diffusion layer on current density requirements for complete cathodic protection can be developed from Fick's Law of Diffusion in simple form: $I_d \cong \frac{215}{\delta}$ ma/sq ft, where δ is in centimeters.—*Corr.*

Prevention of Corrosion in Cooling Water. R. C. Ulmer & J. W. Wood. Corrosion, **8**:402 ('52). General considerations involved in reducing corrosion by several types of cooling-water systems discussed. Objective of treatment is to form protective coating against corrosion but not too thick seriously to affect eff. of heat-exchange surfaces. Treatments include pH control, addn. of antibiologicals, insulation to stop stray-current corrosion, and oxygen removal. Information on lab. research on inhibitors by Drew Co. given. Addn. of chromates in correct concn. stopped corrosion but insufficient amts. caused pitting. Silicate-phosphates gave better results. Mechanism of silica-base inhibitors discussed. Conclusions reached: controlled calcium carbonate method requires too close control; chromates effective in proper concn. but relatively expensive unless small vols. of water involved. Erratic results obtained with systems involving complex phosphates at pH 6.0 and chromate-phosphate combinations. Good results obtained with silicate-phosphate combinations.—*Corr.*

The Pitting of Zinc by Distilled Water and Dilute Solutions. U. R. Evans & D. E. Davies. Corrosion, **8**:165 ('52).

(Continued on page 70)

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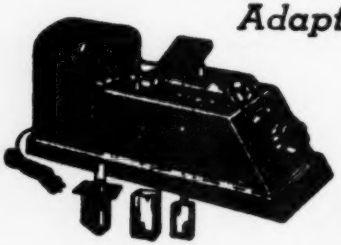

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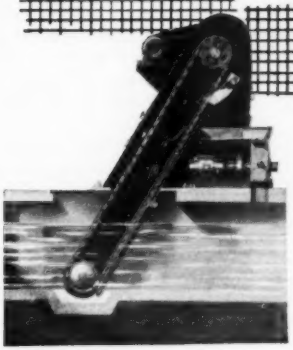

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(*Continued from page 68*)

Object of research was to explain vertical arrangement of pits produced on zinc by distilled water, to study corrosion products, and to explain their formation. Vertical alignment is due to corrosion product from upper pit lodging at points below and screening them from oxygen; lines of pits can also be set up by screening action of polythene thread. Zinc disk whirled in distd. water contg. oxygen suffers no pitting. In stagnant water contg. oxygen under high pressure, zinc remains unchanged; at ordinary pressure, it becomes pitted. Pits contain white matter and are surrounded by white rings (oriented zinc oxide and some β-hydroxide); further from pits are films of interference-color thickness (also oriented zinc oxide), while negatively charged colloid particles appear in liq. Salt solns. produce distr. of attack different from that given by distd. water. Results explained on theory of oxidation and corrosion advanced by Hoar and Evans.—*Corr.*

Cathodic Protection of Moving Underwater Equipment. WILLIAM S. MERRITHEW. Corrosion, **8**:90 ('52). Successful operation of cathodic protection system to safeguard moving underwater equip. at Weymouth Memorial Water Softening and Filtration Plant of Metropolitan Water Dist. of Southern California described. 2 units with combined capac. of 200 mgd process and soften Colorado R. water. Unit installed in '41 without cathodic protection, reliance being placed on anticipated coating of sludge from lime treatment to retard corrosion. By '44 it became obvious that corrosion of members had progressed to point where further protection needed. Tests revealed protective coating plus cathodic protection system was practical assuming ultimate 10% of bare metal surface. Rectifier and iron pipe anodes installed in '44, those in clarifier basins designed to rotate with equip. Test coupons and examns. of structure reveal complete protection, with reduction in potential ranging from 220 to 280 mv. One bay of 800′ of drag chain scrapers installed in second unit built in '49 has exptl. installation of magnesium anodes designed to protect chain, rails, drive shafts, etc., and balance of equip. is coated only. Examn. after 1 yr indicates adequate protection, and supports figures on estd. life of anodes on cathodically protected chain.—*Corr.*

Some Effects of Cathodic Protection on Conventional Paints. L. P. SUDRABIN ET AL. Corrosion, **8**:109 ('52). Use of cathodic protection with metal protective paints is of interest to industry where steel structures are immersed in water or buried in soil. Although both systems of protection offer many advantages, both have some disadvantages. Hence question arises: "Are they compatible and would combination of two systems overcome some or all disadvantages of each?" It is felt that, with conventional paint systems, blistering could be minimized by applying constant potential between anode and painted surface rather than constant current. 4 groups of tests were set up in fresh and salt water. Details of tests given. In fresh water, it was noted that blistering of paint increased rapidly with increasing potential measured against surface of paint film with satd. KCl calomel half cell. Although considerable blistering was observed where potential measured against calomel half cell did not exceed -850 mv, paint films materially assisted cathodic protection. In sea water, it was noted that vinyl paint films blistered increasingly with increasing potential pressure across film. At potentials less than 1,000 mv measured against KCl calomel half cell, very little, if any, blistering was encountered after 1½ yr over that observed on panel not under cathodic protection. On cathodically protected panels, small, pinpoint, white deposits formed, indicating effective policing by cathodic protection. To establish more definitely best combination of cathodic protection and paint, study should extend several years beyond time of initial failure of paint film.—*Corr.*

A Field Investigation of Cathodic Protection in Glass-lined and Galvanized Water Heaters. W. A. DERINGER & F. W. NELSON. Corrosion, **8**:57 ('52). Research started by A. O. Smith Corp. more than 20 yr ago demonstrated that effectiveness of cathodic protection was greatly enhanced when coupled with glass-fused-to-steel coating. Subsequent research and field experience with glass-lined domestic water heaters indicated this principle could, perhaps, be applied to advantage in this product. Glass lining, being inert nonconductive coating, would impose no current drain on cathodic protection device used. Heretofore glass

(*Continued on page 72*)

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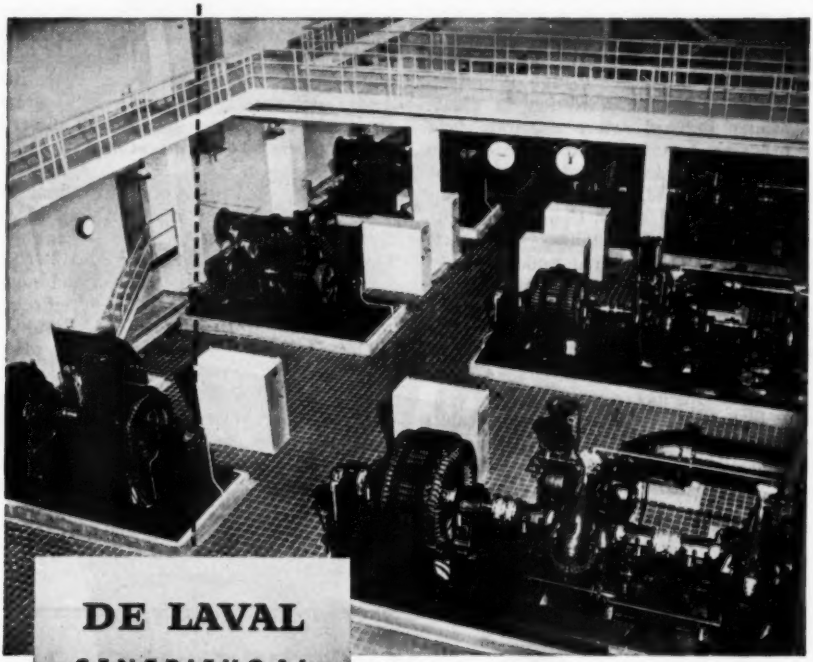

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(Continued from page 70)

lining sole protector of water heater tanks against corrosion, and (as in any mfd. product) always possibility coating might not be perfect. It was thought magnesium anode might serve as substitute to protect steel areas exposed if glass coverage imperfect. To evaluate cathodic protection in glass-lined water heaters, rather elaborate field test program begun, involving installation of 4 glass-lined and 2 galvanized water heaters in each of 12 carefully selected cities in eastern half of U.S. Constr. of tanks used and method of installing magnesium anode shown. Coatings on all tanks damaged deliberately to make possible evaluation of effectiveness of cathodic protection under abnormally adverse conditions. Plans included detn. of current flow, anode life, effect of cathodic protection on coating itself, and possibility of incorporating several cost-saving features in glass-lined water heaters when magnesium anodes used. After installation, heaters were inspected at regular intervals, both visually and electrically. After 1 yr half of heaters removed and dissected. Results of this field test program showed how magnesium anodes behave both in galvanized and glass-lined water heaters under variety of water and performance conditions. Anode life under these conditions detd. and anode life expectancy graphs shown. Photographs of many of dissected water heaters also shown.—*Corr.*

Prevention of Corrosion and Metal Attack in the Steam Water Cycle of the Steam Power Plant. F. G. Straub & H. D. Ongman. Corrosion, 7:312 ('51). Covers potential sources of iron and copper solubility in preboiler cycle and effect of these metals on steel in boiler. Results of studies conducted to det. effect of pH in cycle on soly. of these metals given. These include effect of increasing pH of stream and feedwater by means of controlled addn. of ammonia to cycle. It is shown that, by maintg. pH of 9 in feedwater by use of ammonia, copper as well as iron soly. has

(Continued on page 74)

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(Continued from page 72)

been reduced to very low values. Methods of adding and controlling ammonia in cycle given. Action of reducing chems. in boiler beyond their normal action on free oxygen discussed. This covers potential action of these reducing chems. in reducing iron and copper entering boiler so that they will not come in contact with boiler metal until they have been reduced and thus elim. these metals as potential oxygen carriers.—*Corr.*

BOILERS AND FEEDWATER

Electric Resistance Measurements of Dilute NaCl, CO_2, and NH_3 Solutions for Use in High-Pressure Boilers. K. Wickert & H. Wiehr. Vom Wasser (Ger.), **18**: 310 ('50–'51). Measurements enable detns. of true salt and CO_2 contents of boiler water and definitely detect the effect of raw water on ammonia containing turbine condensates. —*W. Rudolfs*

Chemical Descaling of Boilers. W. J. Sinton. Australasian Engr. (Australia), **1948**:51 (Mar.). A soln. of 33% HCl is circulated through tubes of the boiler; procedure, quantities, and results are described. Alkali-phosphate solns. are also successful over a period of time. Principal advantages of chem. descaling are reduced time layoff and dismantling, cleaner surfaces, and fewer replacements. Scale prevention by initial deionizing is to be preferred.—*CA*

Antinakipin and Its Use in Fishing Fleets. E. G. Pochkin. Rybnoe Khoz., **24**:2:18 ('48). The Antinakipin is prepd. by heating Na_3PO_4, caustic soda, oak tannin, or sulfite liquor, and $K_2Cr_2O_7$ in water at 90°C. The resulting mass is cut into pieces. These are added directly to the boiler feedwater for the elimn. of boiler scale.—*CA*

Causes and Effects of Condensate Contamination. R. T. Hanlon. Pulp Paper Mag. Can., **53**:10:169 ('52). Condensate from intermediate and high-pressure boilers is often seriously contamd. as result of use of steam for process and by Fe, Cu, and other materials which are products of corrosion in condensate system. Adverse effects of these contamns. in promotion of boiler deposits are discussed, as are means for eliminating these contaminants. Application of modern methods of makeup water preconditioning and effect of these methods upon decreasing condensate contamn. are considered. Application of volatile amines (e.g., cyclohexylamine and benzylamine) to control of condensate corrosion is described and data obtained from plant operation are presented.—*CA*

Boiler Care on the Waste Gas Side by the Ammonia Vapor Process. K. Rath. Allgem. Wärmetech., **3**:79 ('52). In order to keep heating surfaces of boiler at side on which combustion gases flow along clean and to guarantee best possible heat transmission, they are exposed to action of ammonia–water vapor mixt. which is condensed at border surfaces between pipes and incrustations by cooling on water side. Incrustations are removed from pipe walls by increase of partial pressure and of vol. of deposits due to chem. reactions. NH_3 also neutralizes free acid so that protection from corrosion is brought about. Brickwork is not damaged in this process.—*CA*

(Continued on page 76)

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(Continued from page 74)

Ammonia and Ammonium Salts in Water Treatment. E. SEYB. Allgem. Wärmetech., 3:49 ('52). Advantages of NH_4OH addns. to feedwater for boilers are discussed. pH value can thereby be so adjusted that water has low alky. and yet corrosion in boiler pumps avoided; furthermore, economical advantage is possibility of recovering NH_3 again from waste water by milk of lime which gives reaction $2NH_4Cl + Ca(OH)_2 = CaCl_2 + 2NH_4OH$. Installation is described. —*CA*

CHEMICAL ANALYSIS

The Versenate Method for the Determination of Calcium and Magnesium in Mineralized Waters Containing Large Concentrations of Interfering Ions. G. R. BOTHA & M. M. WEBB. J. Inst. Wtr. Engrs. (Br.), 6:459 (Oct. '52). Use of disodium dihydrogen versenate for hardness is based on work of Schwarzenbach. Object of present investigation was to extend this method to high mineralized waters containing much higher concentrations of interfering ions than reported by Betz and Noll [*Jour. AWWA*, 42:49 ('50)] and Diehl, Goetz, and Hach [*Jour. AWWA*, 42:40 ('50)]. Addn. of potassium cyanide is satisfactory in overcoming interference from Co, Cu, Ni, and Zn in concns. of at least 1,000 ppm, but no appreciable increase over their limits is shown by Al. No satisfactory treatment was found to suppress Mn or Sn, but for Pb, which titrates as hardness, partial suppression was obtained by addn. of sodium sulfate. In very hard waters sample should be diluted before adding buffer, to prevent pptn. of magnesium hydroxide. For low-hardness water it is advisable to add known concn. of Ca ions before titration.—*H. E. Babbitt*

The Determination of Hardness According to the Wartha-Pfeifer Method. ERNST NOLTE & ANNELIESE MOHNKE. Beitr. Wasser-, Abwasser- u. Fischereichem. Flusswasser- Untersuchungsamt Magdeburg, 1949: 8; Chem. Zentr., 1950 (I):1135. Numerous

(Continued on page 78)

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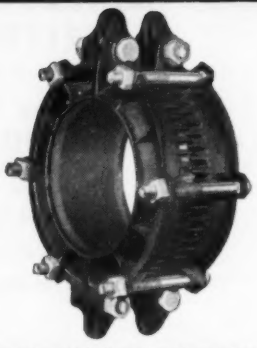

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detns. on artificial and natural solns. showed that within hardness range of 2°–60° hardness can be detd. with great accuracy with Wartha's soln. For softer waters amt. of precipitant should be reduced by half. Accuracy of detn. not affected by addn. of calcite, aragonite, NaCl, or K_2SO_4. Detailed directions given for making detn.—*CA*

Determination of Fluoride in Potable Water. J. PIROTTE & A. BERGER. Bull. Centre Belge Étude et Doc. Eaux, No. 14, p. 241 ('51/IV). Spectrophotometric method is based on decolorization of Al lake of eriochromecyanine by F.—*CA*

Polarographic Determination of Fluorine. W. KEMULA, M. MICHALSKI & Z. ZDRODOWSKI. Prace Glównego Inst. Chem. Przemyslowej (Pol.), **1951**:2:5. Detn. of F in natural waters by means of amperometric method of Langer is possible if sample contains at least 1 ppm of F, interfering SO_4 ions being removed by means of Ba pptn. 0.001 *N* $Th(NO_3)_4$ soln. used for this purpose has to be free of atm. O_2 and at const. pH. Addn. of 1.5% of glycerol to solns. tested removed maxima on thorium polarographic curves, while resistance of electrolytes was only slightly increased.—*CA*

The Lithium Determination in Spring (or Well) Water. E. GRAF & H. BERTHOLDT. Z. Lebensm.-Untersuch. u. -Forsch., **94**:412 ('52). Li detn. in Ca- and Mg-contg. mineral waters was simplified by acidification with HCl, pptn. of SO_4, and removal of Mg and most of Ca in Al_2O_3 column. Soln. is evapd. to dryness, and residue extd. with isoamyl alc. This final residue contains $CaCl_2$ and LiCl, so Ca is detd. by common method and Li calcd. Without chromatographic removal of Mg, isoamyl alc. ext. would contain chlorides of Mg, Ca, and Li. —*CA*

Halogens in Mineral Waters. Enrichment and Determination of Iodides, Bromides, and Chlorides. H. BALLCZO & G. MONDL. Mikrochemie ver. Mikrochim. Acta, **39**:247 ('52). By passing sample through exchange column contg. AgBr, AgI is removed, then by passage through column contg. AgCl, AgBr is removed, and finally column contg. $Ag_2Cr_2O_7$ takes out AgCl, and thus enrichment of each halide is obtained. To obtain I from first column, treatment with satd. soln. of Br in mixt. of AcOH and AcONa is recommended. Cl can be used instead of Br. After removal of excess oxidant, IO_3^- is titrated iodometrically. AgBr in second column can be oxidized with buffered chloride of lime, after which sol. BrO_3^- can also be titrated iodometrically. In detn. of Cl, both $Ag_2Cr_2O_7$ and AgCl are dissolved in NH_4OH, $Cr_2O_7^{--}$ is reduced by EtOH, ppt. of $Cr(OH)_3$ is removed, and dissolved AgCl is repptd. by adding HNO_3 and weighed. It is also convenient to det. total halogen by titration, subtract I and Br contents, and calc. Cl by difference.—*CA*

Micromethod for Determining Volatile Phenols in Waste Waters. G. GORBACH & K. ROHNER. Mikrochemie ver. Mikrochim. Acta, **39**:299 ('52). First det. approx. quantity of phenol present by treatment with diazotized nitraniline as recommended by Fox and Gauge. Take sufficient sewage to yield about 0.1 mg phenol as indicated by above test. Dil. to 2 ml and treat with ammoniacal $CuSO_4$ soln. to remove interfering ions. Add few drops of 30% KOH and remove NH_3 by stream of CO_2. Distill for 8–10 min. Remove distillate, add 10 drops of 6*N* HCl and 0.1*N* $KBrO_3$ soln. until yellow coloration appears; this shows excess of Br. After 15–20 min, add a little KI soln. and starch indicator and titrate excess Br. By reaction of phenol with Br (furnished on adding acid to $KBrO_3$ soln. contg. excess KBr) tribromophenol is formed.—*CA*

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

Activated Silica Treatment of Raw and Waste Waters. A. B. MIDDLETON. Wtr. & Sew. Wks., **100**:85 ('53).

Water Supply for Oakdale Colliery. H. B. FLETCHER. Wtr. & Sew. Wks., **100**:71 ('53).

Fluoridation Experiences in a Small Water Plant. R. P. FERRINGER. Wtr. & Sew. Wks., **100**: 68 ('53).

Renaissance in Rockfill Dams. L. L. WISE. Eng. News-Rec., **150**:4:35 (Jan. 22, '53).

Planning Gave Portland a Great Water System. G. B. ARTHUR. Pub. Wks., **84**:1:60 (Jan. '53).

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Section Meetings

Indiana Section: The 45th Annual Meeting of the Indiana Section filled the Lincoln Hotel in Indianapolis almost to capacity on Feb. 11–13, 1953. Registrations for the technical sessions totalling 317, augmented by 69 ladies' registrations, brought the grand total to 386, a half-dozen short of last year's all-time record.

As in 1951, the program started off with a session on fluoridation of public water supplies. F. J. Maier, sanitary engineer-director of the Div. of Dental Health, Public Health Service, offered current details on the number of installations, experiences with storing large quantities of bulk chemical, information on new compounds available, experience with testing methods and equipment, and the very latest data on the Grand Rapids research. The DMF rate for Grand Rapids children up through 6½ years of age coincides with the base curve of Aurora, Ill. Beyond 6½ years the Grand Rapids curve is halfway between the Aurora base and the Muskegon control. Roy D. Smiley, director, of the Div. of Dental Health for the Indiana State Board of Health, presented the statistics for Indiana with the aid of some very informative charts. A total of 43 public water supplies having adequate natural fluorides, plus 17 already fluoridating, plus 11 with plans approved, will give fluoride protection to 43 per cent of those in the state served by public water supplies, or to 29 per cent of the total state population.

Speaking for the Fort Wayne fluoridation project, Paul G. Fulkerson, chief chemist of the Three Rivers Filtration Plant, stated that 18 months' operation has brought no more problems from fluoridation than come with any water plant operation. Marce Thalheimer, manager of the Batesville Water Works, described the solution feed equipment used on his 250,000 gpd output and stated that the annual per capita cost using sodium fluoride, including 10 per cent equipment depreciation, was 5½¢. He explained that this favorable figure was due to low per capita consumption controlled by complete metering and careful leak surveys rather than price concessions from the chemical supply house. According to Robert J. Becker, assistant superintendent of purification, the Indianapolis Water Co. decided to advertise the date for starting fluoridation because previous telephone calls had indicated several people were taking fluorides prescribed by their doctors. The Indianapolis Water Company was pleasantly surprised when complaints and questions following inauguration of the program amounted to less than a dozen telephone calls.

A divided session was instituted on Thursday morning for the first time and its success demands continuation. In the Purification Section, E. H. Aldrich, chief engineer, American Water Works Service Corp., Philadelphia, Pa., showed pictures of water treatment facilities recently designed for his company along the lines of the so-called package plant. Economies in construction and satisfactory operation make this type of plant suitable for use in the milder climates. The second paper in this section was a discussion on activated silica as an aid to

(*Continued on page 82*)

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Section Meetings

(Continued from page 80)

coagulation, presented by A. E. Griffin, director of the Technical Service Div. of Wallace & Tiernan Co., Inc. After describing the theory of silica micelles gels and their use as a coagulant aid, he told of some results obtained in plant operation from sodium silicate which had been activated with chlorine. His paper was discussed by Marshall P. Crabill, superintendent of purification for the Indianapolis Water Co., and Harvey J. Goetz, of the Dorr Co., whose equipment at the Scottsburg Water Works has been used in plant-scale investigations.

The concurrent General Section heard Philip S. Davy, consulting engineer from LaCrosse, Wis., discuss red water and its prevention. He said that iron removal is not the complete answer to the problem unless the water is adequately stabilized following the treatment process. In the second paper read by Harvey R. Wilke, associate professor of sanitary engineering at Purdue Univ., West Lafayette, a method of evaluating subsurface geological formations as potential water-bearing strata was described. A skilled analyst can interpret air photos and land-use maps to develop suggested areas for drilling industrial and municipal wells, as well as the less favorable producers which may be adequate for residential and farm supplies.

Following the noon luncheon, Harry E. Jordan, as national representative, spoke about some of the current projects and problems of the American Water Works Assn. Resolutions were presented and committees made their reports at the business meeting. The new officers elected are: Herbert F. Zinsmeister, chairman; Harry J. Draves, vice-chairman; and George G. Fassnacht, secretary-treasurer.

At the afternoon session three papers pointed up "Dollars and Sense in Water Works Operation." Thomas J. Burrin, superintendent of utilities at Lebanon, described his plant and operation, emphasizing records and the application of big-business principles. He stated that even some of the smaller water works operations are really big business in their own communities and should be handled as such. Charles L. Hale, superintendent of the Redkey Water Works, told about the money he had been able to save his community by an effective meeting program and the application of other good business principles. Howard W. Niemeyer, superintendent of distribution for the Indianapolis Water Co., stressed the proper use of personnel and material in the operation of a water utility. Under present trends even the smaller plants should make sure that the men are properly selected for their jobs and are provided with mechanical equipment where a cost analysis indicates such expenditures are justified.

(Continued on page 84)

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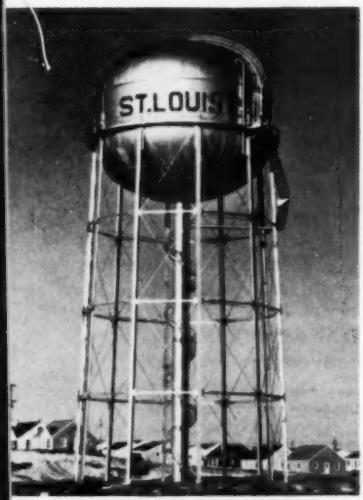

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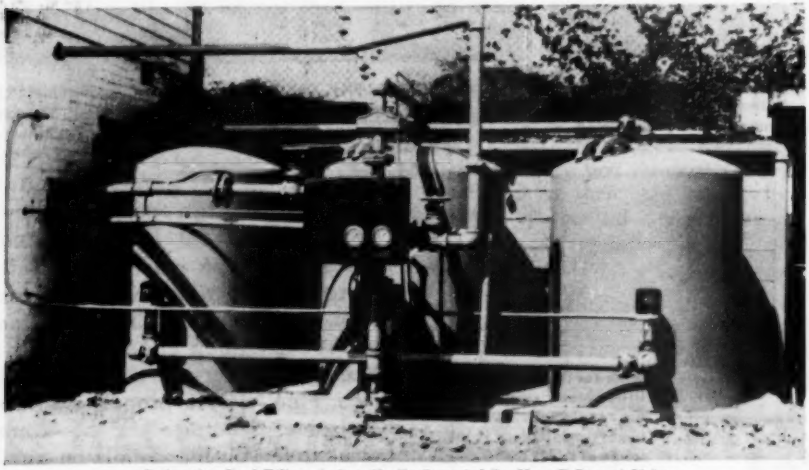
Section Meetings

(Continued from page 82)

At its banquet Thursday night the Indiana Section had the privilege of helping Harry E. Jordan celebrate his 50th anniversary of working in the water supply field. Two other past-presidents of AWWA were present at the head table to join in the festivities. L. R. Howson and Linn Enslow joined Toastmaster L. S. Finch in congratulating Mr. Jordan before his old colleague H. S. Morse made the presentation of a silver tray, properly engraved for the occasion. Mr. Morse himself had just received the Section's nomination for the George Warren Fuller Award a few minutes before. The Section's Bradley Award for membership and attendance went to the Northwest Section of the state, after spending a year down south.

A moving picture of the Purdue University football games last fall opened the Friday morning session. Harry J. Draves, superintendent of the Dept. of Utilities, Michigan City, used pictures to illustrate how 20-ft extensions were placed on the legs of a 750,000-gal elevated water tank to make its operating level meet that of the new tank just recently placed on the system. Clyde Robbins, superintendent at Delphi, reviewed the events of several hectic days last spring when his supply line to town broke somewhere in the flooded creek valley and he found such things as mud and catfish in his clear well. With this encouragement on problems, the meeting was opened to general discussion, which centered largely about various practices and materials used with service pipe installations.

GEORGE G. FASSNACHT
Secretary-Treasurer



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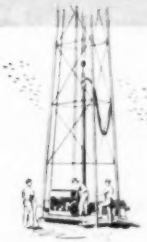
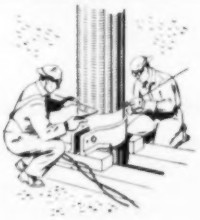


Surveys and test wells

Analyses and recommendations

Pumps, screens, casings



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AWWA 1953 CONFERENCE

Technical Sessions

Water Works Management Division—9:30 A.M.—May 11

Meeting the Needs of Fringe Developments ..... Frederick Wegner
Committee Report: Water Main Extensions ..... L. S. Finch
Management and Operation of Saginaw-Midland Supply Line ..... Alfred Eckert
Appointment of Committees

Water Purification Division—9:30 A.M.—May 11

Activation of Silica ..... C. A. Black
Discussion ..... A. E. Griffin
Stationary Storage of Liquid Chlorine ..... A. S. Woodard, L. L. Hedgepeth
Application of the Microstrainer to Water Treatment in Great Britain ..... Richard Hazen
Discussion ..... P. L. Boucher, A. A. Kalinske, A. W. Consoer
Appointment of Committees

Joint Open Session: Correlating Committees—2:00 P.M.—May 11

Water Works Administration ..... *Discussion of activities*
Water Works Practice ..... *Discussion of activities*

Water Purification Division—2:00 P.M.—May 11

Committee Reports
A Reexamination of Oligodynamic Disinfection ..... Charles Renn
Business Meeting

Water Works Management Division—9:30 A.M.—May 12

Committee Report: Water Use in Air Conditioning ..... Frank C. Amsbary
Committee Report: Water Rates ..... Louis E. Ayres
Promoting Better Public Understanding of What Water Works Service Is Worth .....
M. B. Cunningham, W. V. Weir, L. R. Howson, J. H. Murdoch, S. B. Morris

Water Purification Division—9:30 A.M.—May 12

Do We Need a New Water Quality Yardstick? ..... W. A. Mallmann
Discussion ..... F. W. Gilcreas
Water-Borne Outbreaks—A Statistical Study ..... Abel Wolman, William T. Ingram, A. E. Gorman
Panel Discussion: Lime-Softened Water ..... Merrill Riehl, *Moderator*
Effects on Bacteriological Quality ..... H. O. Hartung
Effects on Main Disinfection ..... Paul C. Laux
Effects on Zinc-Bearing Metals ..... Walter Muhlitner
Election of Officers

Transmission and Distribution Division—2:00 P.M.—May 12

The New ASA Standards for Cast-Iron Pipe
Their Development ..... Thomas H. Wiggin
Resulting Changes in Production Methods ..... Thompson Vann, H. W. Stuart
A Consulting Engineer's Appraisal ..... L. R. Howson
Management's Appraisal ..... W. R. LaDue
Studies on the Mechanism of Corrosion ..... James Lamb III, Rolf Eliassen
Relation of Cast-Iron Pipe Coatings to Corrosion ..... John R. Baylis
Appointment of Committees

(*Continued on page 88*)

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Reliable measuring and controlling equipment

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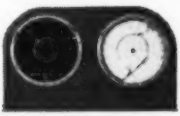

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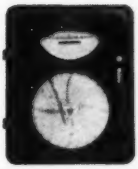

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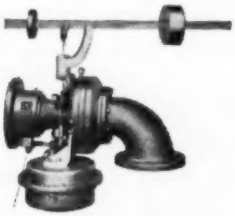

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(*Continued from page 86*)

Water Works Management Division—2:00 P.M.—May 12

The 1952 Drought in the Southwest: Its Supply and Public Relations Problems ..... Marvin Nichols

A Safety Program for the Water Works Industry
- Introduction ..... R. J. Faust
- Supply ..... Jerome Powers
- Treatment and Pumping ..... Oscar Gullans
- Distribution ..... Kenneth A. Day
- Administration ..... Rodney A. Edwards

Business Meeting

Water Resources Division—9:30 A.M.—May 13

Predicting Fluctuations in the Michigan—Huron Lake System ..... John E. Vogt, Donald Pierce

Developing and Controlling Kansas' Rivers: An Engineering Analysis and Report ..... N. T. Veatch, L. R. Howson, Abel Wolman

Managing the Missouri River Projects ..... Dale Maffitt

Appointment of Committees

Transmission and Distribution Division—9:30 A.M.—May 13

Motor Drives for Water Pumping ..... E. O. Potthoff, M. C. Boggio

Application of Vertical Pumps to Water Works Practice ..... Thomas M. Niles

Control of Water Pressure on Suburban Distribution Lines ..... J. S. Williams

Discussion ..... L. S. Finch

Progress Report: Committee on Water Hammer ..... S. Logan Kerr, Hugh Kennison

General Session—2:00 P.M.—May 13

Panel Discussion: The Highway Improvement Problem ..... Harry B. Shaw, John W. Cramer, A. O. Norris, H. E. Jordan

What Mutual Security Agency Means to the Water Supply Industry .... Willard F. Rockwell

Task Group Report: Training Water Works Personnel—Schools and Conferences ..... R. J. Faust, *Chairman;* E. S. Hopkins, Fred Merryfield, A. P. Black, E. R. Stapley

Water Resources Division—9:30 A.M.—May 14

Committee Report: Ground Water Pollution Control ..... Norman F. Billings

Committee Report: Erosion Control on Reservoir Areas ..... B. S. Grant

Water Conservation Methods Used in Industry ..... H. E. Hudson

Interpretation of Pumping Test Data for Wells ..... Russell H. Brown

Business Meeting

(*Continued on page 90*)

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When you consider a new water line, you'll want to use tested steel pipe that is strong, resilient, economical to handle and install, and above all, leakproof. Bethlehem Tar-Enameled Water Pipe meets these qualifications. Here are six good reasons why you'll find it the ideal pipe for water-distribution service:

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Bethlehem Tar-Enameled Water Pipe is made from high-quality steel plate. It's a husky pipe, with great beam strength. It can be handled in multiple lengths, and is unaffected by washouts.

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Bethlehem Water Pipe is designed with a safety factor of about 4 against bursting. It is resistant to water-hammer, and can carry a load of nearly four times the working pressure.

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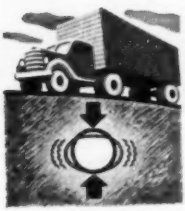
Bethlehem Pipe makes a tight line, with joints made by mechanical couplings, welding or riveting. It safely spans washouts caused by floods, or by leaky joints in lines made of other materials.



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Bethlehem Water Pipe has the resilience to "give" under soil movement. It is immune to surface vibrations caused by heavy vehicular traffic, making possible years of dependable service.

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Bethlehem Water Pipe generally comes in 40-ft lengths. This reduces the laying cost, as only 132 joints are required per mile. It is manufactured in all diameters from 22 in. i.d., and in any wall thickness.

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BETHLEHEM *Tar-Enameled* WATER PIPE

(Continued from page 88)

Transmission and Distribution Division—9:30 A.M.—May 14

Design, Construction, and Functional Relationships of New North Jersey Water Supply Line
C. H. Capen
Design of Wye-Branch Fittings. .....H. J. Chapton, H. S. Swanson, Carlton L. King, W. J. Wilkinson
Panel Discussion: Plastic Service Pipe .....M. E. Flentje, Max Socha, W. D. Tiedeman
Business Meeting

Joint Session: Water Resources and Water Purification Divisions—2:00 P.M.—May 14

Effect of Irrigation Runoff on Surface Water Supplies
Introduction .....M. B. Cunningham
Discussion .....Paul D. Haney, Thomas W. Bendixen, C. S. Howard, J. K. Silvey
Controlling Industrial Pollution of the Passaic River .....Frank DeHooge
The Effects of Synthetic Detergent Pollution on the Operation of the Osawatomie, Kan., Water Softening Plant .....Russell L. Culp, Howard Stoltenberg

General Session on Fluoridation—9:30 A.M.—May 15

An Evaluation of Fluorides in North Dakota Water Supplies .....A. E. Williamson, J. H. Svore
Defluoridation of Municipal Water Supplies .....F. J. Maier
A Rational Approach to Fluoridation .....J. E. McKee
How a Health Commissioner Looks at Fluoridation .....A. E. Heustis
General Discussion

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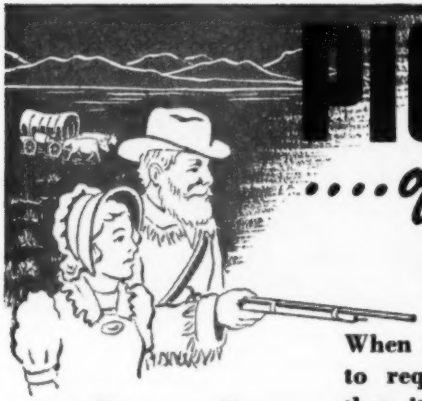
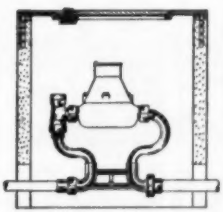


PIONEERS ....of these TIME-SAVING ECONOMIES

When a meter-servicing chore seems to require more time and bother than it is worth, Ford engineers usually come up with a new idea to save time and cut costs. Each of the products in this space was pioneered by Ford to solve an expensive service problem. It pays to refer your problems to Ford FIRST.

RESETTERS

Until the Ford Resetter was developed the only way to raise a too-low meter was to dig up and remake the setting. The modern way to do the job is to remove the meter from between the old couplings, insert the Resetter and connect the meter between the flanged copper tubes.



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The Coppersetter is a complete meter mounting and has been widely adopted for outside meter settings in shallow and medium depth service lines. The word is copyrighted; there is no Coppersetter except that made by Ford.

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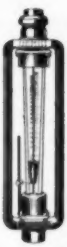

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Chemists and Engineers:
(See Prof. Services, pp. 25-29)

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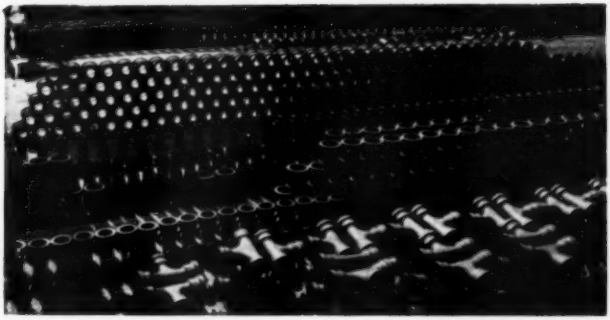

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We offer prompt shipment from foundry stocks: standard Super-DeLavaud centrifugally cast pipe, 18-foot lengths, bell-and-spigot, Boltite Mechanical Joint or Precalked Joint—tar coated, uncoated, standard cement lined or thin cement lined with seal coat.

McWane foundries also offer prompt shipment on 2-inch and 2¼-inch Cast Iron Pipe in 18-foot laying lengths, including Threaded Joints. For complete information, write or telephone—

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Ion Exchange Materials:
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Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Refinite Sales Co.
Roberts Filter Mfg. Co.
Rohm & Haas Co.

Iron Removal Plants:
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Cochrane Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Carson-Cadillac Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr Co.
Infilco Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.

Magnetic Dipping Needles:
W. S. Darley & Co.

Meter Boxes:
Art Concrete Works
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Smith-Blair, Inc.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco Inc.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
Infilco Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
Southern Pipe & Casing Co.
United States Pipe & Foundry Co.
Warren Foundry & Pipe Corp.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Dearborn Chemical Co.
Koppers Co., Inc.
Reilly Tar & Chemical Corp.
Southern Pipe & Casing Co.
Warren Foundry & Pipe Corp.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe, Plastic:
Carlon Products Corp.
Kraloy Plastic Pipe Co., Inc.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.
Southern Pipe & Casing Co.

Pipelines, Submerged:
Boyce Co., Inc.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
Warren Foundry & Pipe Corp.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.
Peerless Pump Div., Food Machinery Corp.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Morse Bros. Mchy. Co.
Peerless Pump Div., Food Machinery Corp.
Worthington Pump & Machinery Corp.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mchy. Co.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

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Ductile iron service clamps offer the important advantages of bronze—at less cost. They are stronger, more ductile—and have a corrosion resistance that is superior to malleable or cast iron.

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Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
Permutit Co.

Soda Ash:
Solvay Process Div.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div.
Cochrane Corp.
Dearborn Chemical Co.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Refinite Sales Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Worthington Pump & Mach. Corp.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
Mueller Co.
A. P. Smith Mfg. Co.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Cochrane Corp.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
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Crane Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James. B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

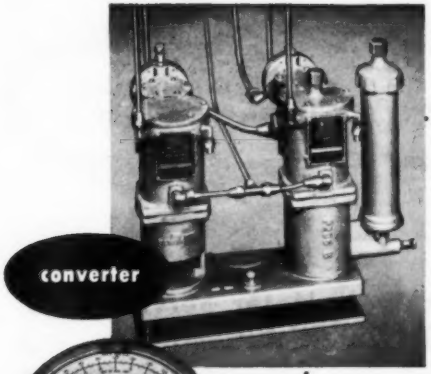
Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.
Worthington Pump & Mach. Corp.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1950 Membership Directory.



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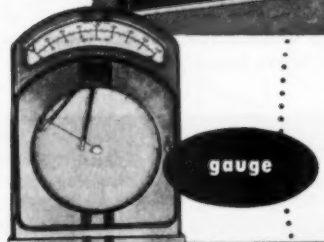

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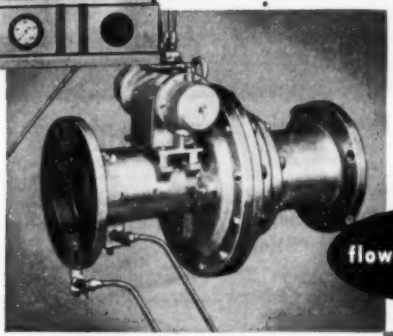

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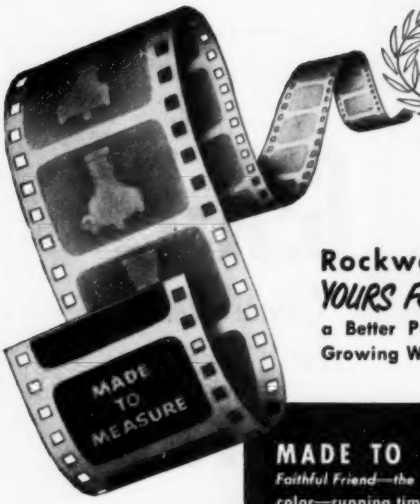

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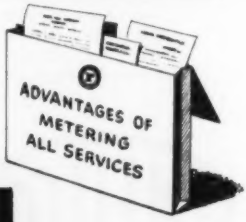

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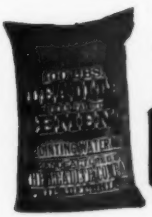

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